The Living Countryside

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A weekly nature guide to the British Isles

80p

ISSUE
109 to 120

IR £1

THE NIGHT-FLYING LONG-EARED OWL

The long-eared owl shows a high degree of adaptation to night hunting – its hearing and sight are excellent and its velvety plumage allows virtually silent flight. Like the tawny owl, it is almost entirely nocturnal in habit. This, and its good daytime camouflage, make it a rarely seen bird.

Long-eared owl (*Asio otus*). Resident bird joined by migrants from the Continent in winter. Occupies woodland, including conifers, as well as open habitats. Sexes alike. 34cm (13½in).

In evolutionary terms, owls are more advanced than most other species of birds, showing a high degree of specialisation and adaptation to a life of hunting. Among the best adapted for swooping down on prey swiftly, silently and efficiently is the long-eared owl. It is not a bird that many people commonly see. Compared to some other birds it is rather scarce but, with over 3000 breeding pairs in Britain and Ireland, it can hardly be described as rare; indeed, there are many fewer short-eared owls and yet they are much more familiar.

The long-eared owl is comparable in length to the jay, jackdaw or pigeon, so it should not be as difficult to see as some of our tiny warblers. Furthermore, it is not inaccessible, as are eagles which nest in remote mountains or rails that hide in vast, impenetrable reed-beds.

A true night owl The scarcity of sightings of the long-eared owl can be explained in three words: darkness, camouflage and silence. The long-eared owl is perhaps our most nocturnal bird, rivalled in this, as in other aspects, only by the tawny owl. Sometimes it ventures out at dusk or dawn, particularly in the far north where nights are short in summer, but in most regions it is strictly a night owl, roosting by day in a quiet, undisturbed wood or copse.

The long-eared owl's camouflage becomes operative in daylight. Favourite roosting sites are branches close to the main trunk of a tree, or among ivy, but even in a comparatively flimsy, leafless hawthorn it merges remarkably well into the background. With mottled and vermiculated (finely striped) grey, buff and dark brown upperparts and boldly streaked buff and dark brown underparts, the roosting owl closely resembles bark or a broken-off branch. In the dappled shade of woodland you are most unlikely to find one simply by searching at random, without prior knowledge of the location of an owl roost.

Special adaptations Good eyesight and hearing are general bird characteristics, but owls have developed these to a high peak of efficiency. Like many mammal predators and other birds of prey, owls have forward-facing eyes; both focus on the same object, allowing perfect 3-D vision.

Even more astonishing is the long-eared owl's ability to detect and kill prey in total darkness. Although such conditions are rare in the natural world, long-eared owls have demonstrated this ability beyond refutation under experimental conditions, detecting just a brief rustle or squeak and flying to it with pinpoint accuracy. Their ears are even placed asymmetrically in the skull, so that the direction of a sound can be determined instantaneously, without needing to turn the head for a series of bearings.

The behaviour of a roosting long-eared owl demonstrates clearly how the discs of feathers around each eye (and therefore adjacent to each ear) help the bird to hear. When undisturbed, the owl rests in a relaxed position, with eyes closed and face looking 'crumpled' and most unlike its usual appearance. Once

Below: The long-eared owl is often seen perching in trees, whereas the short-eared owl prefers to perch on posts or tall tree stumps. Like those of the short-eared owl, its 'ears' are not hearing organs but elongated head feathers, used to convey alarm or excitement to other owls.

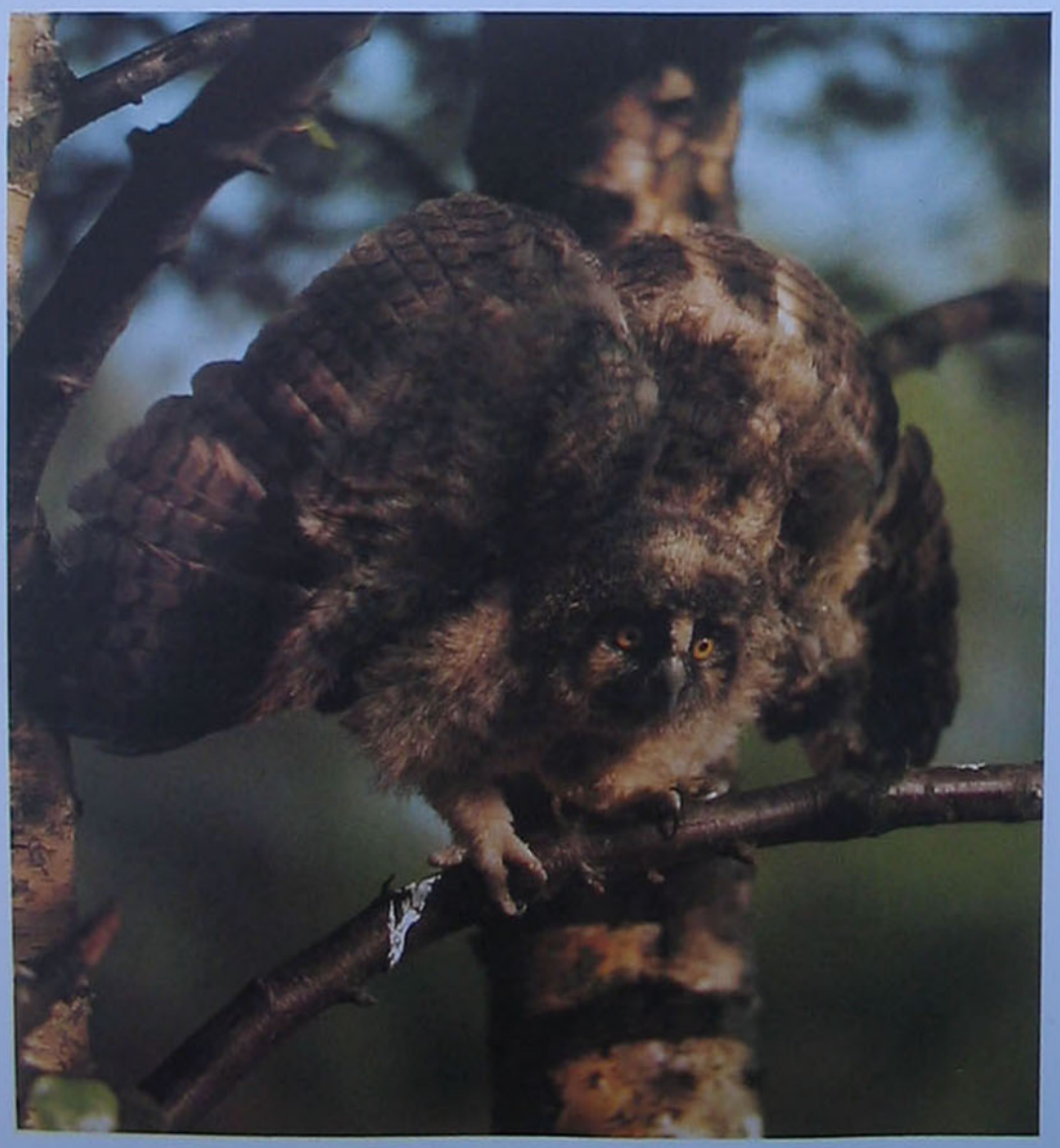
disturbed, however, perhaps because an observer has approached too closely, the eyes open wide and the facial feathers are fanned out – not to help with vision but to focus any sounds on to the ears like a form of parabolic reflector. Typically, the whole bird changes shape on such occasions, from being generally fluffed-out and rounded to being tall, thin and much less conspicuous. Only if absolutely necessary will it fly off. It is therefore very easy to walk past the bird without realising that it is there.

Rival species Despite all its qualities as a hunter, the long-eared owl does have a dangerous rival: the tawny owl. This species is larger and heavier than the long-eared, and consequently 'rules the roost': since both their diet and habitat preferences overlap, tawny owls tend to oust any long-eared owls from their territories. Fortunately, the long-eared owl can survive in a range of habitats which tawny owls rarely frequent. These include coniferous woodland (tawny owls prefer deciduous), isolated groups of trees such as farm shelter belts and copses, and even heathland, marshes or dunes where trees are absent altogether.

Prey and pellets While tawny owls normally hunt from a perch, long-eared owls often hunt in flight, aided by their larger wings. They find prey both in woodland and in adjacent areas, showing remarkable agility within trees and when making a kill. The diet depends on the prey species available. In Ireland the choice of small mammals is restricted to wood mice, brown rats, house mice and pygmy shrews, but in Britain short-tailed voles, harvest mice, bank voles and common shrews are also available. Wood mice are most important in Ireland, and short-tailed voles in Britain.

Above: Long-eared owl chicks begin exercising their wings when only three weeks old, leaving the nest shortly afterwards.

Below: A young long-eared owl in an aggressive display posture.



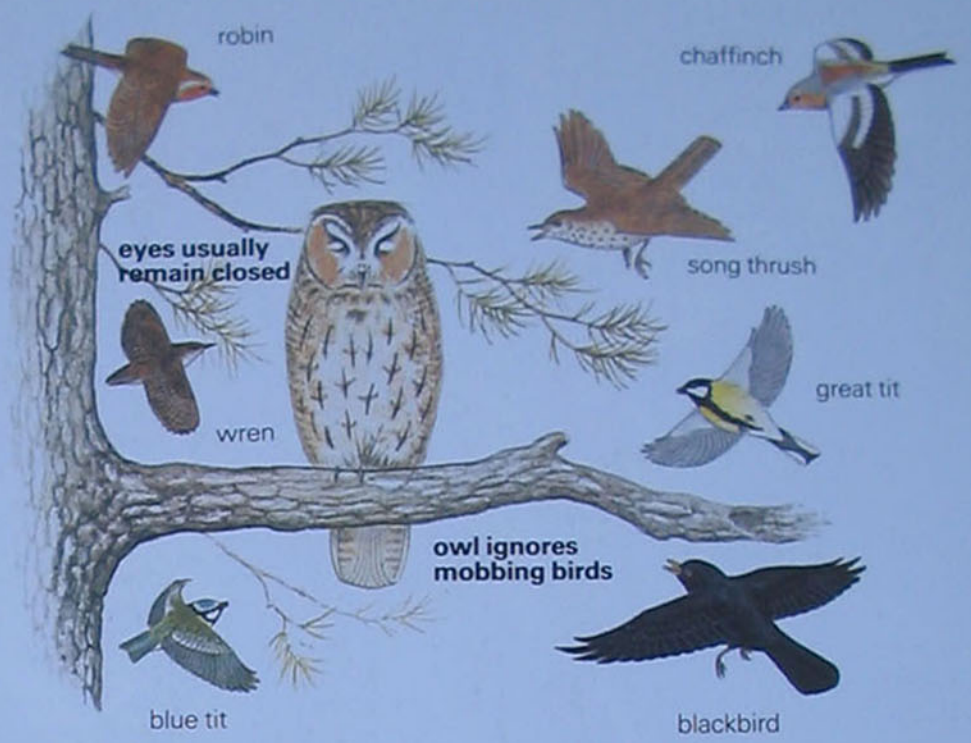
Like other owls, long-eared owls cough up the indigestible remains (bones, skin, fur, teeth) of their food in pellets. Dissection of these shows that, apart from mammals, small birds and large insects such as beetles also feature in their diet. Some individuals seem to specialise in catching birds, raiding their roosts at night – the pellets are an interesting source of recovery of bird rings because of this. Each pellet may contain the remains of several catches, and measures up to 2.5cm (1in) in diameter and 6.5cm (2½in) in length. The best places to find them are beneath the owls' nests or favourite perches.

The breeding season This starts in early spring, and at this time you can hear one of the eeriest sounds of the woodland at night: the male long-eared owl's deep moaning 'hoo-hoo-hoo' call. Each note is separated by an interval of two or three seconds, which makes the call quite distinct from that of the tawny owl, whose hooting is more closely spaced.

The call serves to establish a territory and to attract a mate. Once the territory is established, the pair of owls select a nest – usually the deserted nest of another species of bird or an old squirrel drey (nest). The nests are usually in a tree, but in areas where trees are scarce, bushes often suffice; and if there is no alternative, perhaps in sand dunes or marshland, long-eared owls make nests of their own. They even use man-made stick nests if these are suitably positioned.

Mobbing a roosting owl

Nocturnal owls roost during the day; some are inevitably discovered in their roosting hide-outs by other birds, including tits, thrushes and finches. A remarkable instinctive reaction called mobbing often ensues when the owl is found. The small birds fly back and forth in front of the owl, even dive-bombing it (but without making actual contact). All repeatedly give alarm calls, which draw the attention of yet more birds to the scene, many of which join in the mobbing. The most likely explanation for this strange behaviour is that it alerts all the birds in the area to a potential source of danger. It also helps young birds to learn to recognise predators. In joining the mobbing party, therefore, a bird may well benefit others of its species. The roosting owl does not usually strike back at the attacking birds, but patiently waits for the mob to move on; alternatively, it may leave for a better-concealed roosting spot.



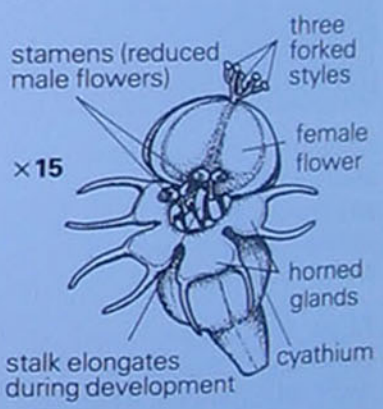
Above: The relative size, as well as the internal structure, of owls' eyes results in night sight far better than our own.

The pure white eggs are usually laid in March, April or May, and may number between two and eight, depending on the availability of food at the time (voles in particular vary markedly in abundance). In a good year all pairs breed, but in a bad year some forgo breeding for that season.

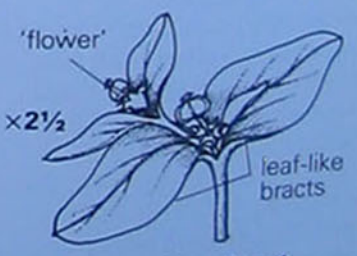
The female lays one egg every other day, and the young hatch at similar intervals some four weeks later. While the young are still small, the male alone brings food for his mate and family, but later both parents are kept busy. This is the other time of year you are likely to hear long-eared owls, because the young have a high-pitched and far-carrying whistling call.

Right: Once the territory is established, the pair of owls select a nest, choosing to use old or deserted nests of squirrels or other birds such as magpies, woodpigeons, sparrowhawks and crows, rather than tree holes like many other owls. The eggs are laid in March, April or May, and number from 2-8, depending on the availability of food at the time. The female lays one egg every other day, and incubates right from the start, so the young hatch at similar intervals some four weeks later. In a large brood the oldest chick may be two weeks older than the youngest.

Above: Wood spurge is easily recognised by the inward-curving, horn-shaped glands around its 'flowers'.



Close-up of 'flower'



Flowering shoot

Above: The 'flower' of a spurge—here petty spurge—actually consists of one female flower surrounded by stamens, all contained within the cyathium.

SPURGES: POISONOUS PURGING PLANTS

Seemingly inconspicuous plants at first glance, spurges are worth a closer look, for their flowers have a structure that is both fascinating and unique. But take care if you handle one because they have a nasty surprise in store—if you tear off a leaf or cut a stem they release an acrid, poisonous sap.

Britain has a dozen or so spurges (*Euphorbia* species), some very rare, in habitats ranging from coastal sand dunes to woodland and waste land. The spurges belong to a large family, the Euphorbiaceae, with more than 8000 species around the world, many of which are economically important. Apart from the spurges themselves, there is only one other common British member of this family, and that is dog's mercury. Compared with many tropical species, which may form sizeable shrubs or small trees, British species are relatively small herbaceous plants.

Unique flowers The flowers of spurges are small and predominantly green which, from a distance, makes them seem dull and uninteresting. Yet they have a unique structure.

What seems to be a single spurge flower is really a reduced head of flowers. In the centre is the female flower, consisting of an ovary with three styles on top. Surrounding the female flower are several male flowers, each reduced to a single jointed stamen. This miniature cluster of flowers arises from the centre of a cup-like structure known to botanists as a cyathium.

Around the rim of the cyathium are four or five elongated and often conspicuously coloured glands, which secrete nectar. Insects—mostly small flies, but sometimes wasps and beetles—are attracted by the nectar to the flowers and pollinate them as they crawl over the surface.

The cyathia and their accompanying glands are borne on a branched flower head, below which lie the bracts. On most plants, the

bracts are green and akin to leaves, but on many spurges they are brightly coloured and sometimes resemble petals. Sun spurge has yellowish bracts, while on cultivated species they can be white or red–for instance, the house plant poinsettia (*Euphorbia pulcherrima*) has large, showy bracts.

Explosive capsules The fruit of British spurges is a capsule with three segments, each containing a single seed. They take only about a month to ripen and you can usually find plants in all stages of development, from buds through flowers to ripe fruits. At maturity, the capsules suddenly split with a loud cracking noise into three parts and the seeds are flung out violently, leaving only the central axis of the fruit.

At the base of each seed (except on those of purple spurge) is a fleshy body known as a caruncle, which contains an oil irresistible to ants. The ants carry away the seeds, dispersing them even further from the parent plant, discarding them intact after eating the fleshy part.

When crushed, the seeds yield an oily juice that can be used as a powerful purgative–hence the common name spurge, which comes from the same Latin root word as purge. However, you should not use the juice for this purpose, because it is poisonous and deaths have been reported resulting from the eating of some species.

Caustic sap One of the most curious properties of our native spurges is revealed if you cut the stem or pull off a leaf. From the damaged surface oozes a milky sap, which coagulates on exposure to the air. This sap is acrid and poisonous–because of this spurges must be handled with care. The larger species produce copious quantities of sap, especially noticeable when the plants are being weeded out of a garden, so take care if you do this. The sap could cause your skin to blister and it would take weeks to heal. In the past, beggars deliberately used to produce blisters in this way to arouse sympathy.

In home medicine the sap of spurges was used to burn off warts; hence the numerous common names for spurges, such as wartgrass, wartweed and wartwort. This practice is now discouraged because the sap burns off the surrounding skin just as easily as it does the wart. The sap was once taken internally as a purgative against intestinal worms, and even against syphilis. However, you should not swallow the sap because, like the oil from the seeds, it is poisonous.

Maritime spurges There are two native species of spurge–the sea spurge and the Portland spurge–that you are likely to come across only on sand dunes and the tops of sandy beaches. Both are perennial species and occur mainly on the southern and western coasts of the British Isles.

Sea spurge is a distinctive plant with its clusters of stiff, usually unbranched stems.

Above: The purple spurge *(Euphorbia peplis)* was once fairly common in southern counties but is now almost extinct in Britain, though it is still widespread along the Atlantic and Mediterranean shores of Continental Europe. One of the maritime group of spurges, this species prefers shingle beaches, where its short branches can spread between the pebbles. The stems are purplish–hence its common name–and the leaves may also have a purplish tinge. The leaves are unusual in being asymmetrical, one side having a rounded lobe near the base.

Below: As its name suggests, the dwarf spurge (*Euphorbia exigua*) is a small plant, often only about 10cm (4in) high. It resembles petty spurge but has narrow strap-shaped leaves with a distinct bluish tinge. Petty spurge is an uncommon weed of cultivated ground and waste places and is rare in the north of Scotland.

Dog's mercury

Apart from *Euphorbia*, only one other genus in the spurge family is native to Britain, and that is *Mercurialis*, whose most common member is dog's mercury (*M. perennis*), pictured above. Mercuries differ from spurges mainly in their flowers, which are borne in clusters on long stalks or hang in catkins, male and female flowers nearly always appearing on separate plants. Dog's mercury is a woodland species and can tolerate very low levels of light. It is common in most parts of Britain but is rare in Ireland and probably not native there.

Left: One of our most common spurges is the petty spurge (*E. peplus*), a tenacious weed flowering in almost any month of the year, provided there is not a covering of snow.

Below right: The fruits and seeds of spurges provide a useful means of identifying different species.

Below: Some spurges found in the British Isles.
Caper spurge (*E. lathyrus*). Doubtful native; more likely a garden escape. Flowers in June and July. Height to 1.2m (4ft).
Cypress spurge (*E. cyparissias*). Another garden escape. Flowers June and July. Height 30cm (1ft).
Portland spurge (*E. portlandica*). Native to southern and western coasts. Flowers May-September.
Broad spurge (*E. platyphyllos*). Native; widespread in the south. Flowers June-September.
Sun spurge (*E. helioscopia*). Common native. Flowers May-October. Height to 30cm (1ft).

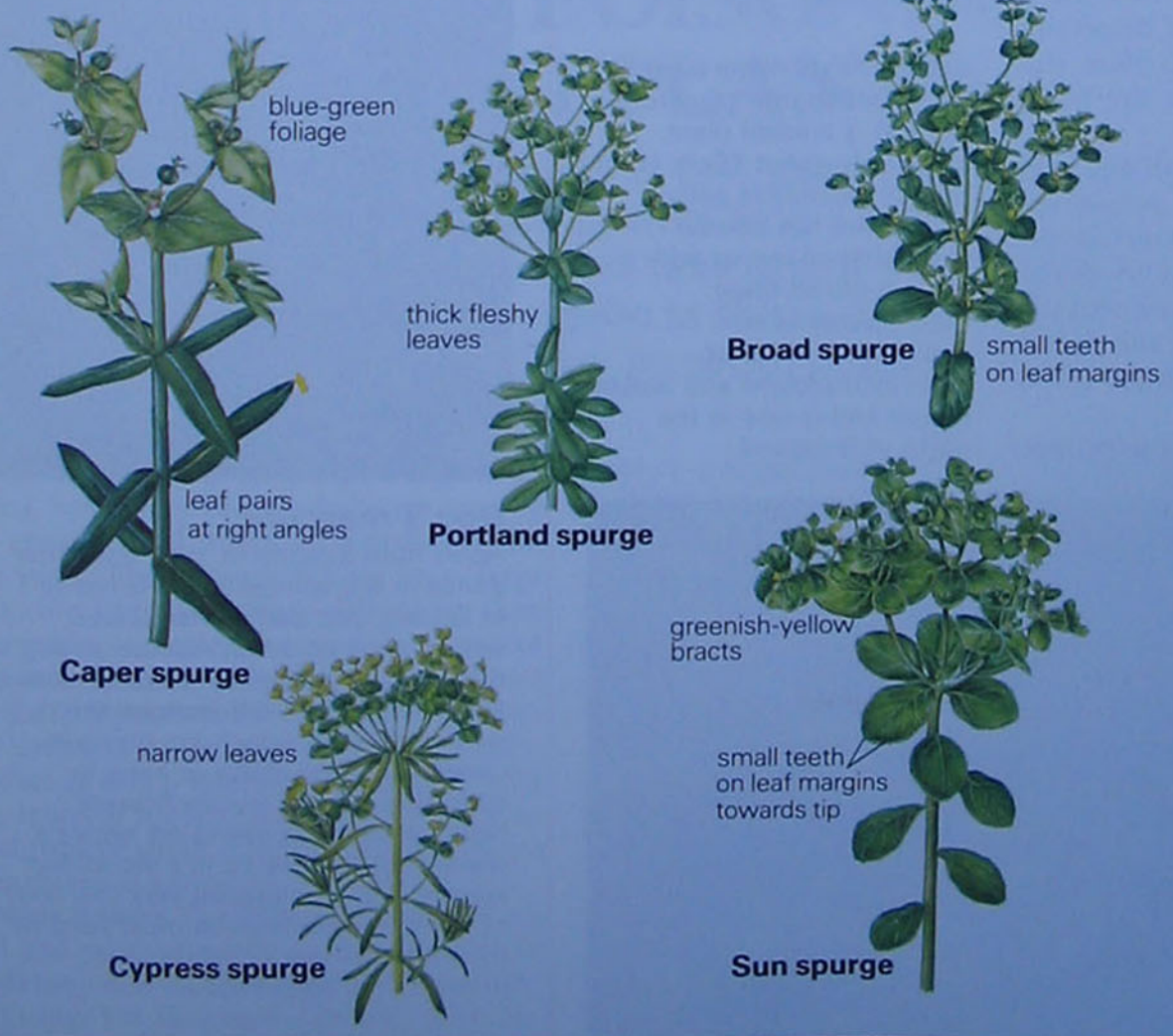
From the short woody base of the plant to the tips of the stems is usually 35cm (14in) or less. The stems are densely clothed in fleshy blue-green leaves. The leaves–unusual in being succulent–are broad and cupped, with the surface quite devoid of hairs. Flowering takes place from July to October, the flower heads being rather compact with just three to six main branches, each bearing flowers.

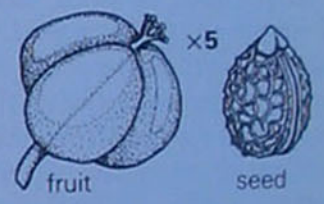
Portland spurge is a similar species but its leaves are not quite so fleshy and they tend to shrivel and fall during flowering, often turning red as they do so. The flower heads are generally larger with more branches; they appear from May to September. Sometimes the flower head has a red tinge similar to that of the ageing leaves. In both the Portland spurge and the sea spurge the glands around the 'flowers' have an elongated horn at each end, the horns of the Portland spurge being much larger than those of the sea spurge.

Weed species The most familiar spurges are, without doubt, those that oocur as weeds of cultivated ground and waste places. Several native species come into this category. All are annuals and usually fairly small plants less than 30cm (1ft) high.

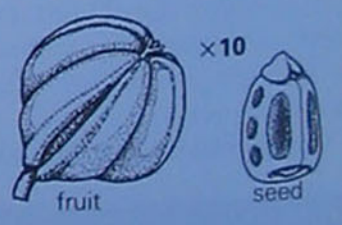
One of the most common species in this group, and indeed of all British spurges, is the sun spurge. One of the easiest ways to identify the sun spurge is by its broad, greenish-yellow bracts. Another distinctive feature is that the leaves have small teeth towards the tip. The

Spurge identification

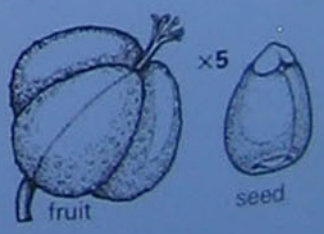




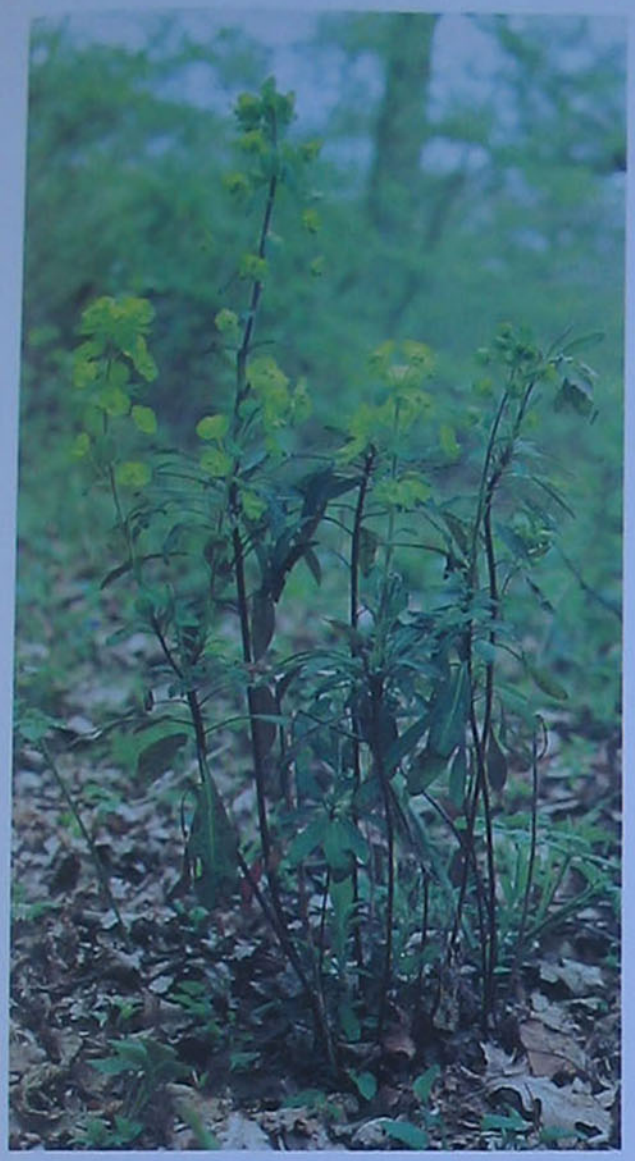
Above: The sun spurge has smooth-skinned fruits, while the seeds are covered with a regular pattern of pits.



Above: The petty spurge has two narrow wings on each fruit segment and the seeds are irregularly pitted.



Above: Wood spurge has similar fruits to those of sun spurge, but its seeds lack pits.



glands of the 'flowers' are green, broad and oval, and lack horns.

The petty spurge is another common species, in some areas being even commoner than the sun spurge. Its leaves are oval and lack teeth, the bracts of the flower heads are green, and the glands possess long slender horns.

The dwarf spurge, as its name suggests, is a small plant, often only about 10cm (4in) tall. It resembles petty spurge but has narrow strap-shaped leaves with a distinct bluish tinge. This species is not as common as the two preceding spurges and is very rare in the north of Scotland.

Broad spurge is even less common, though still widespread in southern England, where it is abundant in some localities. The leaves are broad (as the name suggests) and shallowly toothed along the edges.

Woodland spurges Only one species of spurge is at all common in woodland, and that is the wood spurge. This species produces tufts of stems that bear only leaves in the first year. In the following year the stems elongate and produce a flower head, with the previous year's leaves forming a collar beneath it. The flower head consists of between five and ten main branches. One of the easiest ways to recognise the wood spurge is by the soft covering of short hairs on its dark green leaves and stems. The glands of the 'flowers' have characteristically slender horns, which curve inwards towards each other.

Above: Probably the most common British species is the sun spurge. One of the easiest ways to identify it—and the source of its common name—is by the broad greenish-yellow bracts of its flower head.

Left: The only common woodland species is the wood spurge (*E. amygdaloides*), at least in woodland and hedgerows of southern England and Wales. Further north, it becomes less common and is unknown in Scotland. It flowers in April and May and can reach a height of 80cm (32in).

While fairly common in woodland and hedgerows in southern England and Wales, the wood spurge is less common in northern England and absent from Scotland.

Escaped or native? As well as our native species, there are several others that are widely cultivated. Some have become naturalised in so many localities that it is not clear whether they were ever native to our islands. These include the cypress spurge, with its attractive fine foliage that turns red in autumn, and the elegant caper spurge.

The caper spurge is cultivated for its bizarre growth habit as much as for its attractive blue-green foliage. In the first year it forms a single stout stem, with its narrow leaves arranged in four ranks. In the second year this stem branches, and each branch further divides into two again and again. By the autumn the caper spurge resembles an inverted pyramid, with a single stem at the bottom and an almost perfectly flat top. This species is named after its seed capsules, which resemble capers used in cooking.

Below: Sea spurge (*E. paralias*), one of our two common maritime species of spurge—the other being the Portland spurge.

AUTUMN: SEASON OF MISTS AND HARVESTS

The first shades of autumn fall in that gentle changeling month, September. Sunny days, but longer, cooler nights, then wind and rain, cause plant and animal communities to undergo profound changes in their life-styles. The annual harvest is gathered and stored in preparation for the cold winter ahead.

In early autumn the sun, though in retreat, is still strong by day, drawing moist air upwards from the land surface. The lengthening nights, however, accompany a sharp drop in temperature, bathing the countryside in mist, heavy dew and, on still clear nights, frost. High pressure and its attendant warm sunny days often hold sway, so that summer seems to steal a march on autumn, giving farmers some leeway with late harvesting. Towards October, however, deepening depressions far to the north of the British Isles can put a swift end to this Indian summer. The winds they generate are typically vigorous north-westers which bring chill blasts and squally rain. This turn for the worse has long been associated with the autumn equinox, when the latitude of the sun decrees a day and night of equal length. It is often a foretaste of future storms, the more so in Scotland where October sees the first flurries of snow on the hills.

Throughout summer the life support system of deciduous trees has been the green pigment chlorophyll, which interacts with sunlight to provide the power source to manufacture all the trees' nutrients. With shorter days, and a weakening sun, trees can no longer sustain chlorophyll production and the system begins to shut down. As the green pigment decays, it is replaced with yellow and red pigments which are more resistant to sunlight than the chlorophyll. Yellow predominates in trees such as ash, sycamore, poplar and birches, while red often denotes particularly sugar-rich sap, as with the dazzling leaf-turn of the Canadian maple.

A sudden bout of chill weather after an Indian summer triggers hurried adjustments in pigment when sap pressure is still high, often gilding leaves with especially flamboyant colours. The colours of autumn leaves are, however, mere staging posts in a more radical withdrawal. As ground temperatures drop, the root systems of trees find it harder to extract water, and the leaves are shed so that the tree may husband its resources. Each leaf stem is sealed off by a special layer of cells, and the autumn winds do the rest.

The woodland floor is now awash with the colours of discarded leaves, uniquely enhanced in autumn by fungi. They emerge overnight, drawing sustenance from the decaying litter around them. The type of litter or soil may explain an otherwise unpredictable and erratic distribution of fungi. The scarlet fly agaric, flecked with creamy scales, flourishes in conifer woods along with many

of the other more exotic growth forms. The strange earthstars often pop up in beechwoods, while the giant puffball may lurk in field, hedgerow, or even garden. In general, a hot summer followed by a moist autumn seems to produce the best turn-out of this bizarre community of lowly plants.

A blanket of leaf litter helps to protect not only the roots of trees, but also a host of cold-blooded animals which, like deciduous trees, can no longer maintain the metabolic turnover needed for all-out activity. In October many creep into crevices in fence posts, under stones or bark or indeed, into any refuge where they can hibernate safely in a state of torpor. The hollow withered stems of hogweed make a perfect over-wintering chamber for earwigs, for instance, and a cosy cushion of moss an inviting haven for ladybirds.

Cold as these insects are, there often appears to be a slight advantage in the added insulation given by bedfellows. Scores of ladybirds may huddle together, and several garden snails can cluster underground, cemented in a mucous embrace. Each snail also protects itself by sealing off the aperture of its shell with a mucous plug.

Amphibians and reptiles may also hibernate together, especially in northern areas. Sometimes they are united in their common attraction to a traditionally good overwintering site, but possibly they also benefit from what little collective body warmth they muster when entwined. Communal living among snakes in winter also guarantees readier access to mates in spring. Toads may over-winter with lizards, and both in turn with snakes. Snakes often begin to hibernate about the end of September, but many remain active for up to a month after that if it is warm enough for them to do so.

Faced with up to five months to eke out their summer savings of body fat, reptiles remain active in the warmth of autumn for as long as possible. The tenacity of animals – and plants – in capitalising on the vagaries of the weather is one of the hallmarks of autumn. In some years it is short and sharp, in others it crawls sedately into winter. If the weather is mild, many plants, such as daisies, herb robert, and even poppies, continue to flower late into November. The coastline supports some particularly handsome late flowers in sea rocket, and the sea holly whose colours seem to echo to perfection the soft blue-green mist of the autumn seascape.

Some plants which flowered profusely in spring, such as the sweet violet and wood sorrel, are now quietly engaged in a second wave of self-propagation. Darwin was the first to unravel this largely unseen process and suggest an explanation for it. Only close inspection of the plant's foliage will reveal these curious autumn flowers which, having no petals, no nectar, and almost no pollen, exude no scent and have evidently not evolved to attract insects.

Instead, these flowers are closed and self-fertilising as an insurance against the chance that the main blooms open to a cold wet spring when there are no insects about to fertilise them. Darwin's meticulous experiments demonstrated that these autumn flowers, which include the dead-nettles, vetches and peas, seed just as heavily as their spring counterparts, so providing an ingenious addition to the plant's strategies for survival.

Although bees are now deprived of summer's rich bank of nectar and pollen, ivy offers a late bonanza. In October and November its drumheads of seemingly modest flowers produce a heavy nectar flow, while its pollen is highly accessible to insects with short tongues, such as the numerous flies and wasps. On a sunny day ivy attracts legions of flying insects, including such butterflies as the red admiral, comma and painted lady. They have an invaluable opportunity to stock up on their energy reserves before laying a batch of overwintering eggs, or before hibernation. The fruits of bramble, now pulpy and easily breached as they rot in the autumn frosts, likewise serve as a last-ditch fuelling station, and are gratefully tapped for their sugary secretions.

For many insects, however, in the end there is no escape from the autumn cold. We can readily witness the death throes of flies on our window-sills, like clockwork toys running down. Indoors, spiders such as *Tegenaria* grow to startling proportions on their feast of easily trapped prey, while normally discreet beetles such as the devil's coach-horse boldly break cover in search of victims.

Out in the open, decaying foliage shimmers with a riot of spiders' webs. Especially prolific are the hammock webs of the money spider *Linyphia*. Their elfin 'seine nets', cast wholesale over bramble, gorse and grassy fields, are deadly efficient, and have been shown to trap over 150 sorts of insects. On warm mornings masses of these webs float aloft on rising air, often alighting miles away. The spiders frequently pilot their own webs, apparently using this power of levitation as a convenient means of dispersal.

With the decline of insect life, birds and small mammals switch to autumn's grand profusion of fruits, berries and seeds. A rain of acorns, hazel nuts, sweet chestnuts and other nutritious seeds descends to the woodland floor, to be hoarded by mice, voles and squirrels for winter consumption. Though most mammals specialise in particular sorts of seeds, some enjoy a remarkably catholic diet in autumn. Least choosy of all is the badger, which supplements its basic diet with nuts, berries, windfall apples and plums, and even edible fungi. The fox, too, takes all it can find.

For trees, armies of attentive birds and mammals are valued agents of seed dispersal and accordingly they freely advertise their wares. Many, such as spindle, holly and yew proclaim their ripe seeds by lurid red colours, and offer a sweet, palatable, fleshy coat as a reward. Mistletoe berries glisten an eye-catching white against their evergreen foliage, and are especially relished by thrushes. Jays, which skulk shyly in the depths of the woods in summer, may now be seen flying high over oakwoods, their crops gorged with acorns which they cache in the ground against leaner pickings in winter. Inevitably some of these hoards are forgotten or are scattered by plundering animals, to the benefit of the parent oak. Jays play a specially intriguing role in the spread of oak-woods uphill, since the tree has no other means of sending its bulky seed in this direction. (The seeds always fall downhill.)

At first, autumn appears to offer a limitless bounty for wildlife. Much is short-lived, however, and as the season wears on the food supply becomes patchy. Some birds, such as the robin and kingfisher, now annexe a feeding territory for themselves and defend it fiercely against rivals. Most birds, however, choose strength in numbers, forming large nomadic flocks, perhaps the better to discover the whereabouts of dwindling resources. Starlings fall on elderberries in squabbling hordes, while tits and finches comb the woods for beechmast, spindle and other manageable seeds.

In a good beechmast year they are often joined by bramblings, which migrate to escape the grip of their native Scandinavian winter. Many other birds adopt the same strategy, resulting in a huge influx of autumn migrants. Typical of foggy October nights is the thin plaintive 'seep' of redwings which, along with fieldfares, navigate across the North Sea to join our thrushes in exploiting the berry harvest. Tens of thousands of pink-footed geese make the journey from Iceland, flighting noisily into Scottish stubbles and pastures.

These, at least, we can distinguish as foreign visitors, but for others it becomes impossible to establish nationality. Our estuaries, for instance, now throng with redshank and other waders from polar regions, mingling freely with British representatives of the same species. Many British blackbirds and song thrushes leave in autumn for the relative luxury of southern Europe, while others of their kind arrive from abroad.

By mid-November our plant and animal communities have therefore made often far-reaching adjustments for their well-being and survival, and now brace themselves for winter.

SCAVENGING DUNG BEETLES

Dung beetles play a vital role in the ecology of the countryside by removing manure and burying it in the ground for their larvae to feed on. The adults and the larvae have enormous appetites, often eating their own weight of dung in one day.

Above: The dor beetle (*Geotrupes stercorarius*) unfurling its wings before take-off. Large numbers of these beetles can be seen swarming over cattle pastures on summer evenings, frequently crashing into cattle—manoeuvrability is one of their weaker points. They are sometimes called 'lousy watchmen' since they can be infested with brown mites (seen above on the beetle's abdomen), and because they fly in the early evening—when night watchmen go on their rounds.

It certainly cannot be said that dung beetles have the most charming of habits, yet their importance as scavengers must not be denied. In conjunction with numerous flies, they play a major part in the removal of mammal dung, particularly that of the larger herbivores—so much so that without them a large part of our countryside would disappear under a blanket of cowpats. In Australia, where there are no native dung beetles to clear up after the millions of introduced sheep and cattle, this has indeed become a major problem.

Several kinds of beetles and larvae are found in animal manure, but the true dung beetles belong to the group known as the lamellicorns (a name which refers to the cluster of flaps—lamellae—at the tip of each antenna). Within the lamellicorn group British dung beetles fall into two families—the Geotrupidae (dor beetle, wood dor and minotaur), in which the jaws are clearly visible from above, and the Scarabaeidae (English scarab), in which the jaws are concealed.

Excavating a dung store One of our largest and most familiar dung beetles is the dor beetle which, at 16-25mm (⅔-1in) long, is a shiny black with a bright metallic blue or green underside. It is associated mainly with cow dung and is usually seen flying over cattle pastures on summer evenings.

Mated pairs stay together and work as a team when they find a suitable cowpat. The adults squeeze the food—which is mainly fluid—out of the dung with their jaws and then bury the bulk of the cowpat, usually at night, to provide sustenance for the larvae. The female uses her front legs and her large jaws to dig a shaft (up to 60cm/2ft deep) under the dung, and then excavates a number of oval chambers. The male helps to remove the soil and brings bundles of dung into the chamber.

Food for the young The female lays an egg in each chamber and then both adults leave. Each chamber contains sufficient dung for the fleshy, white, C-shaped larva to complete its growth during the next few months. The larva pupates in the surrounding soil and the new adult emerges during the following year.

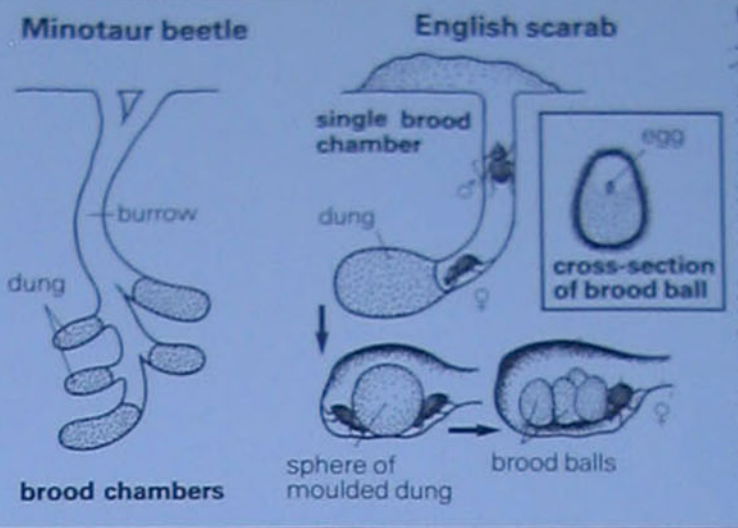
By burying the dung, the dor beetle en-

Armed for battle

Several of our dung beetles—notably the English scarab and the minotaur (above)—have horns on the head or thorax. The horns are always larger in the males, some females having none at all, but no British species have horns which reach the sizes found in some tropical dung beetles. The main function of the horns appears to be fighting between rivals, the males waging battle with one another in much the same way as stags. Horn growth is linked to the amount of work done by the male—the less they work, the larger their horns.

The dung larder

The minotaur beetle, in common with many dung beetles, excavates a burrow in which to store food (dung) for its larvae. The burrow, built entirely by the female, comprises several chambers. The English scarab however, has only one chamber in its burrow, which both adults excavate. The male transports dung pellets to the chamber while the female moulds them into a rough sphere. After a few days she breaks this up and forms 'brood balls', into each of which she lays a single egg, finally sealing them with more dung. When the eggs hatch and develop into larvae there is enough food to last until they are fully grown.



sures that the manure does not dry out before the larvae have completed their growth. It also guarantees them a certain amount of protection from their enemies, although they are not completely safe even then. A smaller dung beetle, *Aphodius porcus*, sometimes invades the dor beetle's burrow, destroying the eggs and laying its own in the ready-stocked chambers.

Wood dor beetle The dor beetle has several close relatives, including the extremely common wood dor beetle (*Geotrupes stercorosus*). This is similar to the dor beetle, but only 12-19mm ($\frac{1}{2}$-$\frac{3}{4}$in) long, and it often has wing cases showing a green, blue or purple iridescence.

It occurs in many habitats but seems to prefer woodland, where it may be found on rotting fungi as well as dung. Its life history is the same as that of the dor beetle.

Bull-like beetle The minotaur beetle (*Typhaeus typhoeus*) derives its name from the male's two horn-like processes which point forward from the thorax. There is also a third somewhat smaller horn between the two larger ones. The female has virtually no horns and rarely exceeds 15mm ($\frac{1}{2}$in) in length, whereas the male commonly reaches 20mm ($\frac{3}{4}$in). Both sexes are normally glossy black.

The minotaur is found mainly in southern England and Wales, usually on sandy ground, and can be seen at most times of the year. Swarming may occur on warm evenings, especially in autumn, which is the main breeding season, but otherwise the beetle spends most of its time on or under the ground. It feeds mainly on rabbit droppings but occasionally turns to deer or sheep dung.

As in dor beetles, the dung is buried as food for the larvae, but the shaft is not necessarily sunk close to the dung. The female does all the digging, the male's horns saving him from this arduous task. He does, however, scoop out much of the excavated soil, and brings in most of the food, often guiding the rabbit droppings with his horns.

The male also defends the burrow, sitting in the entrance with his horns projecting while his mate excavates. Any other males coming too near the burrow or trying to steal

a pellet of dung are attacked, the horns of the combatants clashing together in battle until the weaker male beats a hasty retreat.

Our native scarab The only scarab beetle we have in Britain is the English scarab (*Copris lunaris*). Black and shiny, sometimes with a brownish tinge, it is 15-20mm ($\frac{1}{2}$-$\frac{3}{4}$in) long and easily recognised by the single horn standing erect in the middle of its head. Both sexes are horned, although the female's horn is smaller than that of the male.

This species is quite rare in Britain, being confined to certain localities in southern and central England, normally on sandy soil. It is associated mainly with cattle dung and can be found from May to September.

Above: All the larger British species of dung beetles excavate burrows in which to store dung for their larvae to feed on.

Left: The wood dor beetle (*Geotrupes stercorosus*) prefers woodland habitats, where it invades dung and rotting fungi.

Below: The English scarab (*Copris lunaris*), at 15-20mm ($\frac{1}{2}$-$\frac{3}{4}$in long), is identifiable by the single horn which stands erect in the middle of its head.

Below: This dor beetle, in common with all other dung beetles, has large spiky front legs which resemble rakes, and are used to dig through the dung and excavate burrows.

TEEMING MUDFLATS

A transient habitat, mudflats are visible only when the tide is out. Few people venture on to this difficult terrain to witness at close quarters the myriad life inhabiting it.

Britain's tidal mudflats represent some of the most fertile land, biologically, that we possess, being more protein-productive than the cornfields or rich cattle pastures that may have contributed to their soil.

Slow but sure formation Mudflats are formed in estuaries where, lacking the energy to transport a cargo of silt any further, the rivers have dumped it. Silt is collected by rivers throughout their ever-downward journey to the sea. In its upper reaches a fast-flowing stream can erode and transport boulders and big stones, deriving the energy necessary from the steep gradient of its course. But as it flows nearer to the sea, the heavier burden of stones and gravels can no

Above: Digging for lugworms in the mud of the Wash. The only people with regular business on mudflats are bait-diggers who search for lugworms and ragworms, and cocklers who pick up the molluscs by hand as they lie partly exposed on the mud or rake for them with a special implement.
The material from which mudbanks are built varies widely from estuary to estuary—some are sandy with relatively large particles, while others are composed of very fine silt.

longer be borne along; and by the time the river approaches the sea-level of its estuary it is bearing only the fine muds and silts that travel in suspension. The relatively sluggish flow of an estuary causes much of the mud to be dropped, and this deposition is increased when the fresh river water mingles with the tidal salt water of the sea. By a process known as 'flocculation' the suspended sediments are attracted to each other and, clumping together, they grow bigger and heavier until they fall. As this process continues, mudbanks grow with every tide.

Once a mudbank has started to accrete, the process is self-perpetuating. The dumped material makes the water shallower and, since water flows less swiftly in shallow areas, it is therefore less capable of carrying a load. More mud is dropped. The deposition continues over hundreds of years until a mudbank is high enough to support vegetation–at which point saltmarsh succession takes over in a bid to create solid land.

These changes from bare mud to saltmarsh community take hundreds of years. Sometimes, in the over-deepened valleys of the West Country, for example, which have been filling their estuaries with mud since the end of the last glaciation, the mud deposits may be as much as 30m (100ft) deep. But whatever the depth of mud, it is always the shimmering surface layer–in contact with life-giving light, water and air–that supports the chain of life from algae and bacteria through worms and shellfishes to fishes and birds.

The tidal rhythm All mudflats share the experience of tidal inundation twice every 24 hours. This tidal rhythm governs the lives of all the creatures which live in, on and over the mud.

The tidal rhythms bring violent changes of environment–from dried-out mudbank baked by sun or lashed by rain or snow, to a habitat bathed in salty estuary water–which call for adaptation on the part of the inhabitants. They must sit out the unfavourable periods in as much safety as they can devise, waiting for conditions to improve.

Such problems are shared with creatures of the open seashore, but on the mudbanks there are other problems which effectively limit the number of species able to live there. Varying salinity is the major problem: sometimes almost full-strength sea water washes in, and sometimes, after heavy rain for example, a much higher proportion of fresh water. So the creatures inhabiting the mudflats as permanent residents are highly specialised to cope with this changeable medium. There are relatively few species, but they occur in vast populations, hidden from view within the mud or in the murky water flowing over it.

Tide in Soft mud is easy to burrow into and, with its structure of fine particles (unlike the coarser grains of sandbanks), it is suitable for permanent burrows.

Many of the worms and shells of the mudflats conceal themselves in the mud itself, probing above the surface into the tidal water to feed. The Baltic tellin, for example, one of the most widespread creatures of estuary mud, is a mollusc which lies hidden below the surface at all times, but is equipped with siphons for filtering organic material from the water. It can also feed directly from the mud

Above: *Hydrobia* snails feed on mudflats both when the tide is in and when it is out. These tiny snails, each no larger than a grain of wheat, occur at very high densities on fine mud. When the tide has just ebbed they crawl over the exposed surface, feeding on detritus. After an hour or so they burrow and continue to feed on organic material on the mud particles. When water covers the mud on the next tide, they emerge from their burrows and float, hanging upside down at the surface, trapping yet more food from the water. As the tide falls they sink on to the mud and the cycle begins once more.

Above right: Swans paddling about on mudflats pitted with lugworm casts. Birds represent the top of a chain of plant and animal life that makes up the complex community of the mudflat.

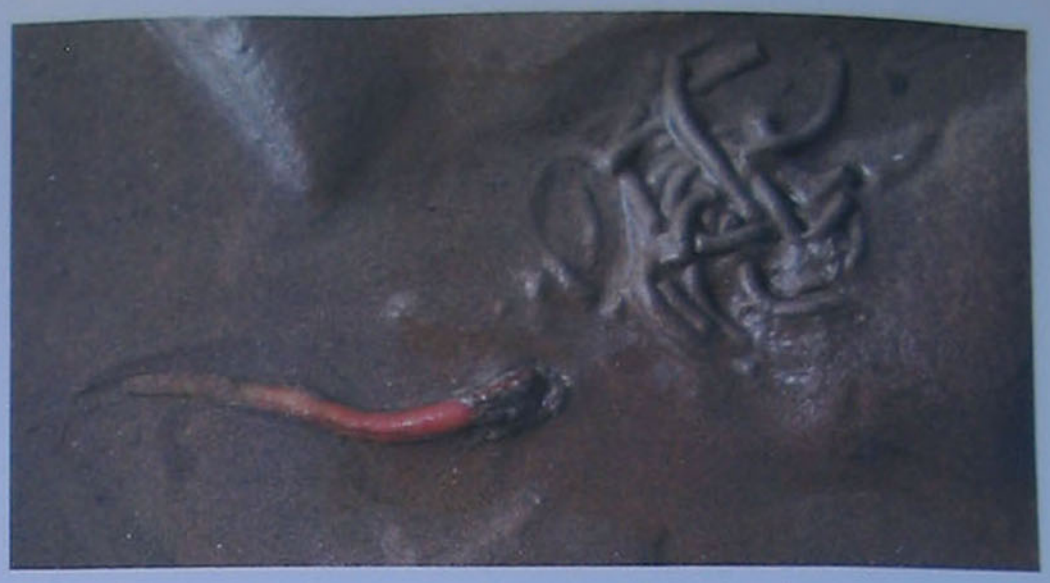
Below: One inhabitant of mudflats to watch for–the common cockle.

surface, using one siphon as a kind of vacuum cleaner to suck up minute particles of organic debris and living algae. This is also the method used by the peppery furrow shell to gain a meal. This mollusc, with markedly flattened shells, has a large foot muscle which allows it to burrow deeper than the Baltic tellin. Another mollusc, the common cockle, hardly burrows at all, the upper edges of the two valves often standing clear above the mud.

Another abundant burrow-dweller is the sandhopper *Corophium volutator*, a crustacean. Its U-shaped burrow conceals this animal when the tide is out, leaving the mud surface pocked with tiny holes. When the tide is in, however, and feeding is possible, *Corophium* crawls over the surface, picking up tiny fragments of organic debris with a pair of legs. It can also feed within the burrow, sucking material into its mouth from the water current passing through it.

Many of the estuarine worms also spend their lives buried in the mud. The lugworm and ragworm are probably the best known, but they in fact have very different life-styles. The sedentary lugworm is a detritus feeder, spending most of its life at the bottom of its U-shaped burrow; swallowing the very mud in which it lives, this worm extracts and digests the organic component and then backs up the tail shaft of the burrow to reject the inedible portion as the familiar worm cast.

The ragworm, by contrast, is an active predator, although it does have a more or less permanent slime-lined burrow. This worm, with its characteristic red line of blood vessels running down the length of its back, reaches out of the burrow to scavenge on the mud and to catch creatures like the abundant opossum shrimps as they pass by.



Above: Lugworm and lugworm casts on mud. As the lugworm 'eats' mud from the head shaft of its U-shaped burrow, more subsides into the burrow to take its place, leaving the characteristic small depression found a few inches away from the cast. The cast itself is formed from the inedible portion of the mud swallowed by the worm.

Below: Ducks on a muddy drainage channel at low tide—note the saltmarshes bordering the mudbanks.

The tidal cycle is crucial to the lives of the mud-dwellers and although life is easier when the tide is in—food is available and the worst excesses of the weather can make no impact—they are beset by predators which are also active during the high water period. The ubiquitous shore crabs scurry across the mud, hunting and scavenging, while fishes swim in to take advantage of the exposed invertebrate life. Grey mullet, for example, suck up the mud, straining out living organisms and organic debris, and they also graze on the surface algae. The flounder, most typical fish of the estuary, is a carnivore, feeding on worms, crustaceans or molluscs.

Tide out When the tide covers the mudflats, their life seems as remote as the far-off jungle—but when the tide ebbs the flats become part of the visible world once more, with the very obvious coming and going of birds and the tell-tale signs of many other forms of life.

The mud surface itself may be thick with tiny snails of the genus *Hydrobia*, seen feeding before they burrow beneath the surface. Worm casts point to the presence of sheltering lugworms in their underground galleries, while shallow grooves in the mud indicate the place where mullet sucked the surface a few hours earlier. Star-shaped markings reveal the underground position of a peppery furrow shell which touched the mud with its probing siphon, reaching out in all directions in search of food when the tide was in.

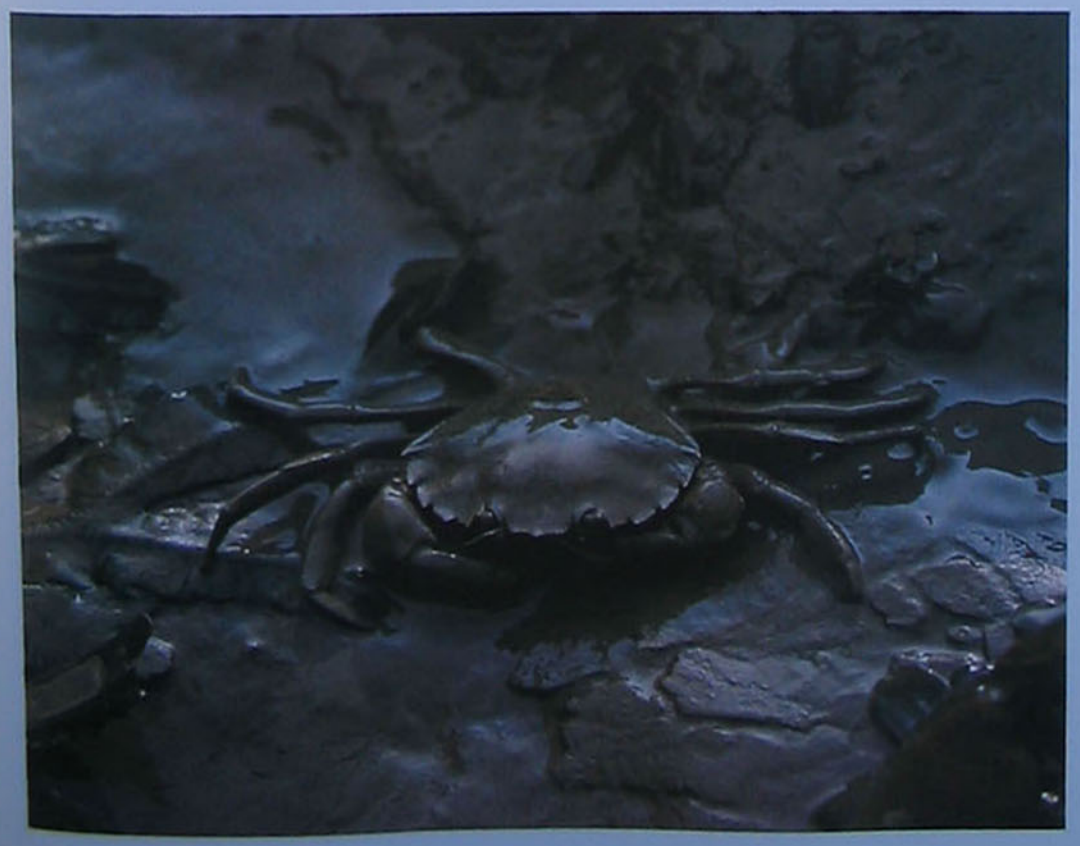
The surface of the mud is not uniform, but is often crossed by drainage gullies. Quantities of empty shells accumulate in such gullies—each different shell pointing to the presence of its species as a member of the living community. There may also be stony patches sufficient to support a mussel bed. The mussels, along with oysters, represent the true filter-feeders of muddy water. Filtering food from the water is easier at sea, where

Above: When the tide is out a vast area of estuarine mudflats may be exposed – they form ideal feeding grounds for a wide variety of birds, ranging from waders, through ducks, to the gulls shown here.

more creatures employ this method of feeding, than in the silty waters of the mudflats where filter and respiration mechanisms can easily become blocked by fine particles. Cockles, too, are usually more abundant on clean sandy beaches, but can be found on mudflats.

Probably the best way to appreciate the vast numbers of living creatures hidden in the mud is to watch the birds that descend on the mudflats. Curlew, redshank, dunlin, plovers, godwits and ducks of all kinds fly in to feed or roost when the tide allows. Autumn and winter is the time to see these birds, when the resident herons, cormorants and shelducks are joined by vast numbers of waders that survive the winter by feeding on the rich invertebrate life of the mudflats.

Below: One of the many hunter-scavengers that appear on the mudflats, the common shore crab can find prey both when the tide is in and when it has ebbed.



These waders arrive in their thousands, trickling in from their breeding grounds from July onwards and reaching a peak around the turn of the year. The different species are able to feed amicably together on the same mudflats because each chooses a different victim, or a subtly different time to exploit it. The waders find food by touch, taste and movement, watching for tell-tale signs of a retreating worm and searching the mud with their sensitive beaks. Creatures lying exposed at the surface – the *Hydrobia* snails and the mussels, for instance – are no more vulnerable than the crustaceans, molluscs and worms concealed within the mud, for the birds are well-equipped to winkle them out. For example, long-billed curlews feel for the deep-burrowing lugworms and ragworms, while short-billed dunlin catch the partly hidden *Corophium*. Beak length is important, making it physically possible for different birds to reach prey living at varying depths – each bird species can exploit different prey.

As the tide floods in and begins to cover the mud, the birds crowd together on the steadily diminishing mudflat, feeding until the last possible minute. But when, at last, the mud is covered, the birds retreat to roost on nearby fields or saltmarshes.

Feeding time for these birds is governed strictly by the availability of the mud and so, whether it is day or night, they must feed when the tide is out. The same regime dominates the life of all the inhabitants of the mud itself; they must shelter from predators such as birds when the tide is out, and feed, hoping not to be caught by a fish, when the tide is in. Because of the ebbing and flowing of the tide the inhabitants of the mudflats are always on the move – either up or down their burrows or away to roost.

SINGLE-CELLED ORGANISMS

Although most species are too small to be seen with the naked eye, representatives of the 50,000 or so species of single-celled organisms known as protozoans are found in every aquatic environment, including the bodies of animals.

The phylum Protozoa consists of a huge array of diverse organisms which all have one feature in common: they consist of only one cell. Although a single-celled entity may at first be thought of as being extremely lowly, many free-living protozoans are relatively advanced and complex creatures. This is because, in addition to the nucleus and cytoplasm found within most typical cells, protozoan cells also contain other minute structures enabling them to feed, move and reproduce in an independent fashion. Most are thought of as animals, but some have distinctly plant-like characteristics, causing many authorities to refer to all protozoans simply as organisms.

Protozoans vary in size from a few thousandths of a millimetre to a maximum of about 3mm – the size of, say, an uncooked rice grain. They are found in water almost wherever it occurs: not only do they inhabit the sea and fresh water, but many species live inside animals. They may live inside an organ such as the gut, or in the bloodstream, and in doing so they often invade the very cells of which the organ – or blood – is composed. Some of these are harmful parasites, some harmlessly share a food source, and some are positively useful to their hosts, forming a symbiotic relationship. Some protozoans can also live for some time without water. If their habitat dries out they encyst, developing a hard casing in which they await more favourable conditions.

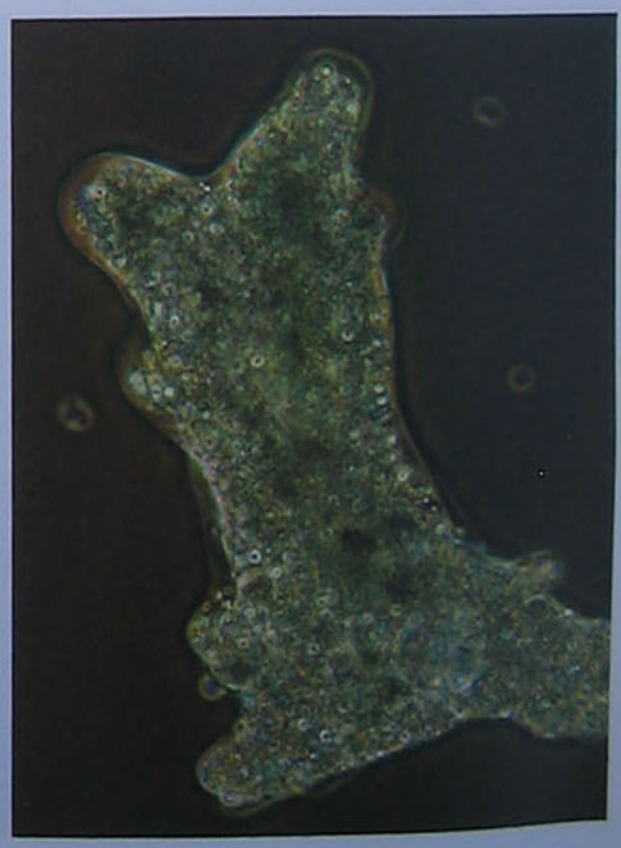
Above: Dozens of colonies of *Volvox* crowding to the water surface. These colonies may consist of hundreds of individual organisms, clinging together in a spherical formation. Larger colonies can be seen without the aid of a microscope, appearing as dots the size of the full stops on this page.

The simple life Cells are the basic units of structure in animals and plants, and may be numbered in their millions. The main biological functions of higher animals – such as movement, feeding and reproduction – are carried out by means of truly complex limbs and organs, all of which are composed of an enormous number of cells.

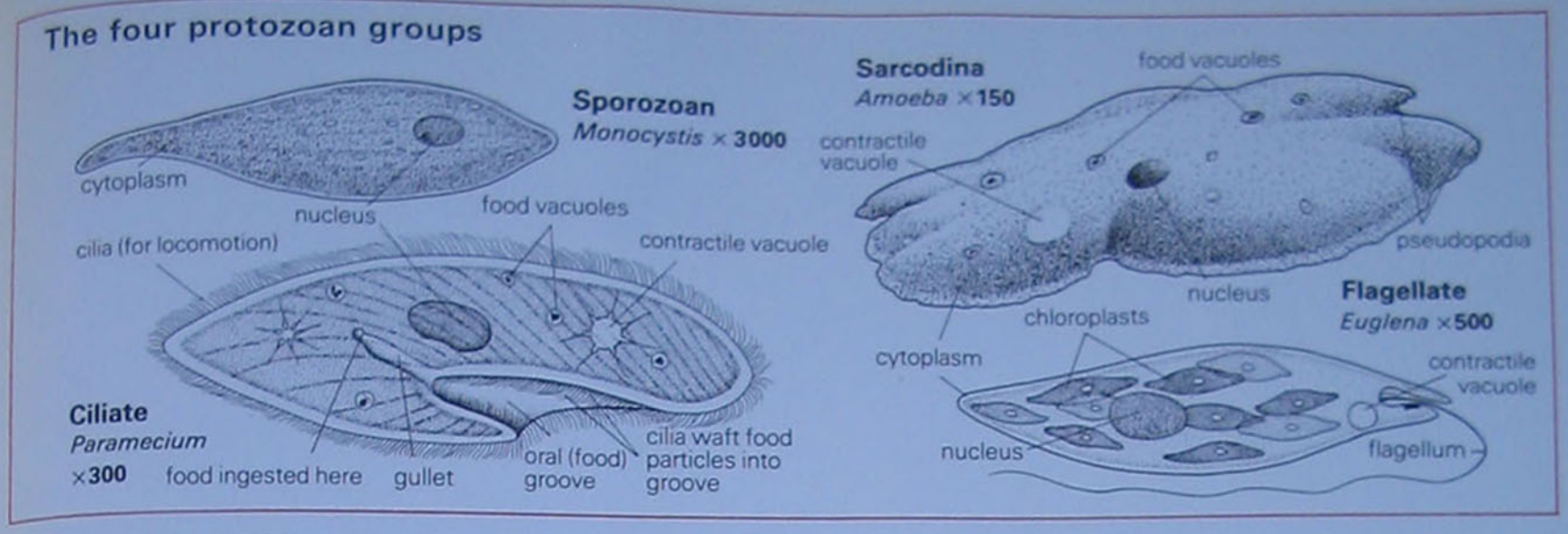
Despite the fact that protozoans consist of only one cell, they are able to carry out many of the functions of higher organisms – movement, feeding, reproduction and so on – because they possess structures within the cell called organelles.

Features of a protozoan Like a cell of a larger animal or plant, a protozoan cell possesses an outer cell membrane surrounding a small quantity of jelly-like fluid which is called protoplasm. The protoplasm contains a nucleus – the structure storing the genetic information of the cell and the functional information on which the organism operates throughout its life. The remaining protoplasm apart from the nucleus is called cytoplasm.

Another interesting feature of protozoans



Right: An amoeba stretches out its pseudopodia. The small grain-like shapes inside the animal are food vacuoles.



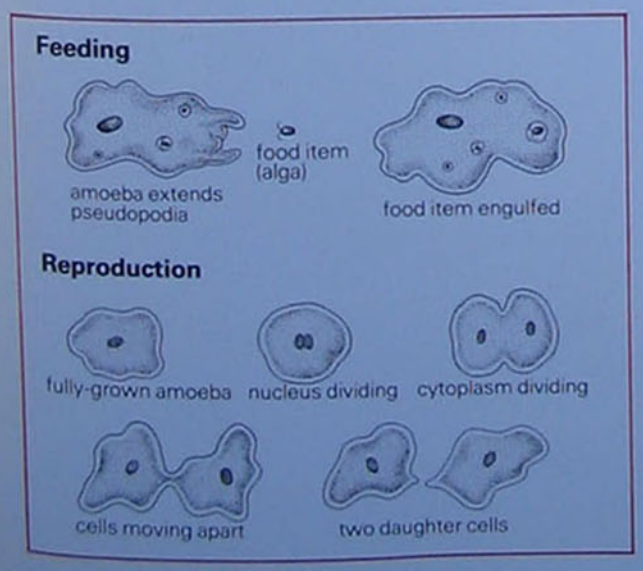
Above: *Paramecium bursaria*, a ciliate. This is a common protozoan found in ponds and ditches. Living inside the organism are numerous single-celled algae, which always occur in this species. The two species have a symbiotic relationship: the algae gain a protected environment, and the protozoan is thought to benefit from any excess sugars the algae create.

Right: *Euglena*, a flagellate. On most individuals the single whip-like thread (the flagellum) is visible. The packets of chlorophyll (the chloroplasts) appear yellowish in this picture.

Left: An amoeba performing two of its basic functions. In the upper illustration it ingests food: the food particle is engulfed along with a small quantity of the surrounding water, in which it is digested. The second function is reproduction by binary fission. The nucleus divides, then the cytoplasm divides, leaving two daughter cells.

lies in the fact that all the species of one major group, the ciliates, have more than one nucleus: usually two. There are even some minor groups containing species with up to a hundred nuclei. No cells of multi-celled animals, and no plant cells, have more than one nucleus, so in this respect protozoan cells are unique.

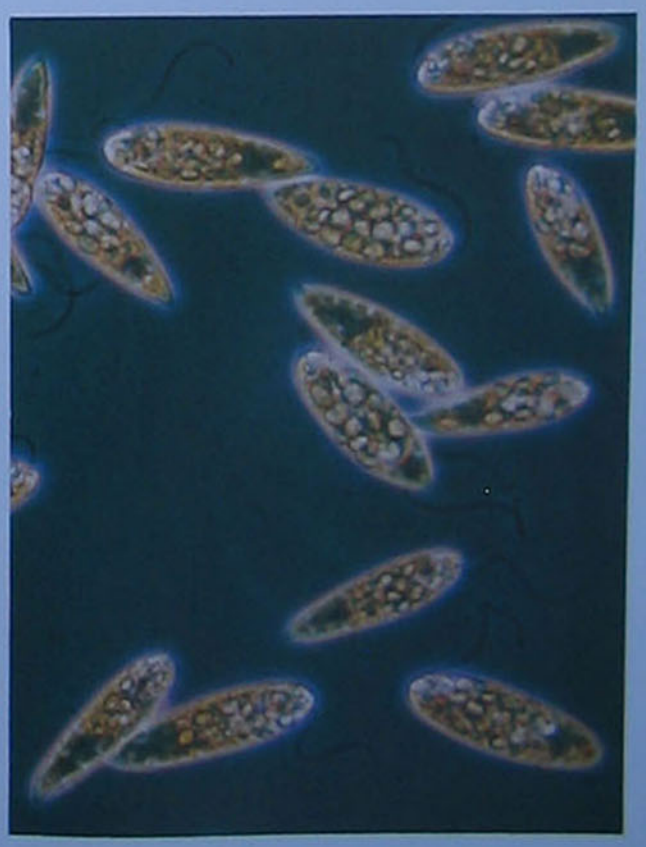
Besides a nucleus (or nuclei), the cytoplasm of a protozoan contains one or more vacuoles. These are intervals within the cytoplasm, and there are two entirely separate kinds. A food vacuole is formed when a food particle has been ingested into the protozoan and is in the process of being digested. A contractile vacuole is formed as an exit point for excess water, enabling the protozoan to regulate its water content.



A protozoan does not need lungs or gills for it can absorb all the oxygen it needs directly through its cell membrane. Neither does it have a circulatory system, for it is so small that digested food passes from the vacuole directly to all parts of the organism.

Many protozoans possess hair-like outer organelles which they can beat back and forth in the water. Short extensions of this kind are known as cilia, and longer ones are known as flagella (cilium and flagellum in the singular). While both these organelles are used in a swimming action for movement, cilia are often used in the process of feeding. A protozoan with cilia (known as a ciliate) may also have a mouth-like opening into which the cilia waft suspended food particles.

Protozoans do not have any special organelles for reproduction. Their commonest method is to divide in two, creating two daughter cells. There are also species which reproduce by this method and sexually. Many 'metamorphose' into mobile male gametes



and non-mobile female gametes which fuse, resulting in fertilisation and the production of a zygote (fertilised egg), and a new generation of protozoans.

There are some 50,000 known species of protozoans, and here we look at the four groups into which they are classified.

The flagellates These are the protozoans with flagella. It is to this group that the plant-like protozoans–the phytoflagellates–belong. These contain chlorophyll: like plants, they use this to create food, with the help of energy from the sun. In doing this, they are the cause of the difficulty in defining protozoans as animals, for no other animal possesses chlorophyll.

The flagellates without chlorophyll are called zooflagellates. Like all other protozoans, they feed on either living or dead organic matter, eating microscopic plants, animals and fragments of their remains. They also absorb nutrients dissolved in the water.

The sarcodines This group includes the amoeba and its many relatives. An amoeba resembles a tiny jelly-like organism that is constantly altering its shape. It has locomotory organelles known as pseudopodia, which are temporary extensions of the cytoplasm into which the rest of the organism flows in a streaming movement. Pseudopodia can form at any part of the amoeba's body surface. They also play a vital part in the feeding technique, in which the amoeba surrounds a food particle between two pseudopodia which then close together, engulfing the food.

The sarcodine group also includes the foraminiferans. These are tiny protozoans with shells; they occur in vast communities in the sea, and as the ages pass their dead remains sink down and accumulate on the seabed. This is how chalk is formed, a rock composed of countless millions of shells in layers hundreds of feet thick in England and northern France.

The sporozoans All members of this group, *Monocystis* for example, are parasites. The sporozoans have a life-cycle in which no particular stage can be referred to as the adult. Individuals develop into spores which, depending on the species involved, may metamorphose and then divide themselves into many further individuals in a process of asexual (non-sexual) reproduction. All sporozoans also have one phase of their life in which they reproduce by sexual means–creating the spores of the next generation.

Typically, the various stages of the sporozoan life-cycle occur inside animals. They may parasitise a worm that is eaten by a bird, inside the body of which the next stage of the cycle takes place. The group includes parasites causing malaria and many other diseases.

The ciliates These protozoans are relatively advanced and are characterised by possessing many cilia for feeding and moving about; they have the most complicated body structure of all the protozoans. Their bodies have a fixed shape, and they possess a 'mouth' and a special organelle for the ejection of waste material. The movement of the cilia shows a high degree of co-ordination–for example, in the ability to direct a feeding current into the mouth. Some ciliates, such as *Paramecium*, are highly mobile. Others, such as *Stentor*, are normally sessile.

Above: *Vorticella* is a ciliate with a stalk which it can coil up or extend, combining security with freedom of movement.

Below: A colony of hundreds of *Vorticella* individuals attached to a pondweed root.

GENTIANS OF THE BRITISH ISLES

You don't have to go to Switzerland to see a gentian. Britain boasts several species of these beautiful flowers, in lowland habitats as well as upland, though not all have the characteristically vibrant blue colour of the alpine species.

Above: The alpine gentian (*Gentiana nivalis*) is one of our rarest native species of gentian, being confined to a few Scottish mountains. Each plant consists of a tiny rosette of leaves giving rise to an erect slender stem bearing brilliant blue flowers. Sometimes just a solitary flower is borne, but there may be as many as 20.

The gentians form a large, widespread group of plants and are found growing in many different types of habitat and climate. They are renowned for the clear blue colour of their flowers, which has attracted plant collectors, gardeners and artists alike for centuries. The colours of the alpine species are particularly famous for this. However, by no means all gentians have blue flowers. Some British species have purplish, mauve or dark pink flowers, and many gentians found in South America or New Zealand have spectacular red flowers, while yet others are white or yellow.

Flower structure The gentian flower is shaped like a narrow bell formed from four or five petals. For most of their length, the petals are fused together into a tube, inside which are the male and female parts. The tube gradually widens towards the top and then expands into four or five triangular lobes, the number depending on the species (though on some, such as the autumn gentian, this number may vary, even within the same plant).

If you carefully compare the flowers of British gentians you will see that they fall into two groups. Some have a fringe of long fine hairs at the base of each petal-lobe. Other gentians lack this fringe of hairs, but have a tiny lobe lying between each pair of large petal-lobes. All British gentians have either one of these features or the other, but not both. Botanists classify the first group into the genus *Gentianella* and the second into the genus *Gentiana*.

Role of the hairs The fringe of hairs on *Gentianella* species shuts off the entrance to the flower tube and prevents unwanted insects from crawling down to steal the nectar secreted near the base. Only pollinating insects such as bees are strong enough to push

Above: The Chiltern gentian (*Gentianella germanica*) flowers in August and September, producing mauve flower tubes about 3cm (1¼in) long.

Left: The autumn gentian (*Gentianella amarella*), another species that flowers in late summer.

aside the fringe and reach the sought-after nectar.

When a pollinating insect lands on the gentian flower, it thrusts its proboscis through the stamens to reach the nectar, in so doing inadvertently collecting pollen on the back of its head. The pollen is then transferred to the stigmas of another flower. Only when all the pollen has been shed from the stamens does the stigma within the flower tube begin to mature; this way the possibility of the flower pollinating itself is avoided.

Although the flowers of gentians are adapted for pollination by such long-tongued insects as bees and butterflies, the nectar is often 'stolen' by insects biting a hole through the base of the flower tube and drawing off nectar that way. This does the flower great harm as it then has little chance of being successfully pollinated and so will produce no seed.

The fruit of a gentian – whether the plant belongs to one genus or the other – consists of a long cylindrical capsule surrounded by the withered remains of the flower. When ripe, the capsule splits open to release the tiny seeds.

Gentians with fringes Our most common gentians all belong to the genus *Gentianella*. That is, they all have fringes at the entrance to the flower tube.

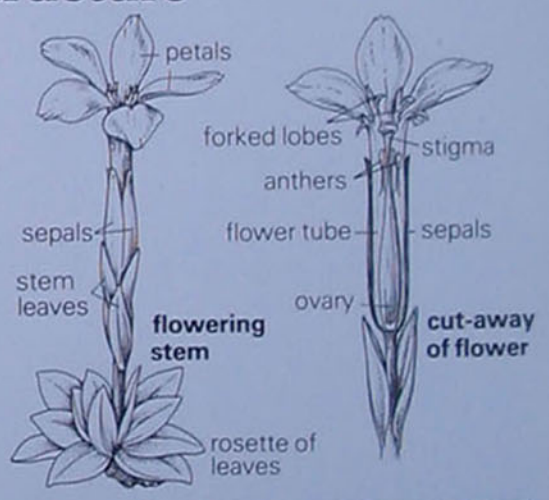
The autumn gentian thrives in open upland pastures and is more commonly known by its alternative name of felwort, probably a contraction of feldwort which means plant of the fields. It is one of the more common species of gentian found in Britain, unlike the slightly smaller early gentian, which is native only to the British Isles, being confined to the chalk grassland of southern England.

The field gentian can be found on chalk and limestone soils, growing in fields and on slopes. Its flowers have four lobes, which serve as a useful feature for distinguishing it from the autumn gentian, which is similar in many ways but whose flowers usually have five petals each. However, this is not an infallible guide to identification.

The only other British gentian belonging to

Spring gentian structure

Gentians are divided into two genera on the basis of their flower structure. Those in the genus *Gentiana*, such as the spring gentian (*G. verna*) shown right and below, lack hairs at the tube entrance and have tiny lobes between each of the petals. Gentians in the genus *Gentianella* are the reverse, being hairy but with no lobes.



Left: The marsh gentian (*Gentiana pneumonanthe*) is one of our loveliest native gentians but sadly it is becoming increasingly rare. It grows in moist lowland heaths and bogs, both habitats threatened by land drainage schemes. Like many British gentians, this species is late to flower, being in bloom from August to September. The flowers are sky-blue with pale dots on the inside of the petals and broad, greenish-coloured—almost translucent—stripes running down the outside. The stripes are thought to help guide bees to the centre of the flower. The whole plant can sometimes grow to 30cm (1ft) high.

the genus *Gentianella* is the Chiltern gentian, a species found in the same habitat as the early gentian. The two species are very similar, except that the leaves of the Chiltern gentian are much broader-based than those of the early gentian.

Rare gentians The second group of gentians, belonging to the genus *Gentiana*, are either uncommon or rare in Britain. One such is the marsh gentian, a lowland species that grows in moist heaths and bogs. During recent years it has decreased in numbers in many areas, probably due partly to over-collecting and partly to the reduction of suitable habitats as more and more sites are drained for farming.

Two species of gentian are so rare that they are protected by law and it is an offence to pick, uproot or damage them in any way. One of these, the alpine gentian, is a tiny plant, often a mere 2cm (1in) tall and rarely reaching a height of more than 10cm (4in). It has brilliant blue flowers and grows on rock ledges at high altitudes (730-1050m/2400-3450ft) on a few Scottish mountains.

The growing season is very short in montane areas and, if a plant is to produce seeds successfully before the end of the season, it must complete its life-cycle quickly. In the case of the alpine gentian, which is an annual species, its seeds germinate in late spring or even early summer when the last of the snow has cleared. The tiny seedlings grow rapidly and flower before the end of August. After fertilisation, the seeds form and, at maturity, are jerked out of their capsule by the wind and fall to the ground, where they lie until the following year.

Britain's second protected gentian is the spring gentian, whose flowers are larger than those of the alpine gentian and just as dazzlingly blue. It is restricted to two areas of the British Isles: Teesdale in northern England and parts of western Ireland.

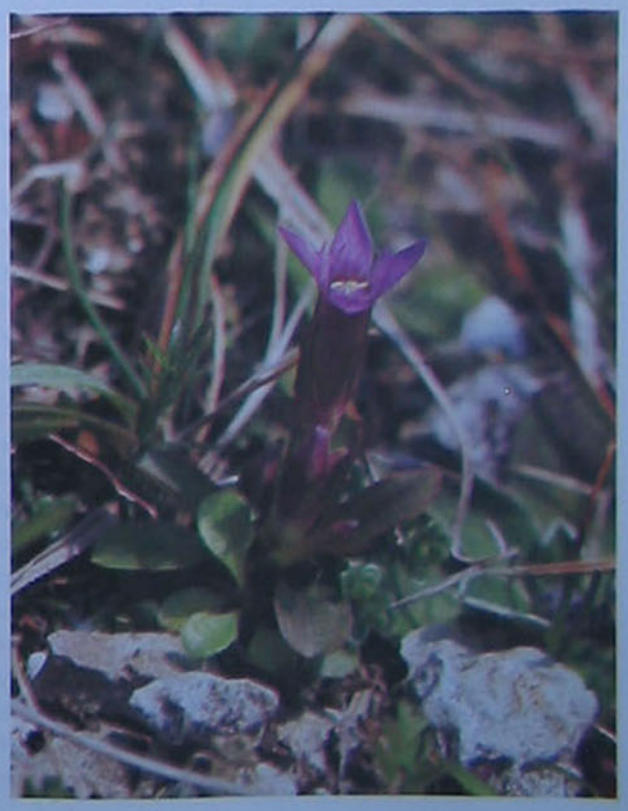
The reason for the intense blue colour of the flowers of these two species is not fully understood. But it is thought that, as with many other alpine flowers, it helps to make the plant conspicuous to pollinating insects in their native habitats, where there are fewer insects than elsewhere.

Medicinal value Many species of gentian are grown in gardens and they have a long history of cultivation, for they were originally planted for their medicinal value.

According to legend, the medicinal properties of this group were discovered by a king called Gentius (hence the word gentian) who, two centuries before Christ, ruled Illyria, a region in what is now mainly Yugoslavia. Medicinally, an extract of gentian roots was used as an antidote to poison, especially that of animal stings and bites.

In Britain, herbalists had at first to rely on supplies of gentian from the Continent, until it was discovered that our own autumn gentian was just as effective.

Above: The field gentian (*Gentianella campestris*) is a plant of limestone and chalk soils. It is still common in northern Britain but becoming rare in the south and east of the country. Unlike some other gentians, the field gentian always has four petals to a flower. It is in bloom from July to October.



Right: The early gentian (*Gentianella anglica*) is native only to the British Isles, hence its specific name. It is, however, a rare species, being confined to the chalk grasslands of southern England. Its flowering period is from May to June.

DEFENCE TACTICS AMONG INSECTS

Because of their small size, no insects can put up a fight against an attacking bird. Instead, they have developed ingenious protection devices. The pug moth, for instance, is disguised as bird droppings, while the bombardier beetle emits a cannon-like explosion.

Above: The lappet moth, which rests on leaf litter during the daytime, escapes the attention of predators by closely resembling its background of dead leaves. Besides its autumnal reddish-brown colouring, it adopts a peculiar resting posture in which it pushes forward its hindwings beyond the front margin of its forewings, so that its normal moth shape is completely disguised.

Opposite right: The beautiful merveille-du-jour moth rests on tree trunks and stone walls during the day, relying on its resemblance to lichen for concealment.

Insects have numerous enemies, ranging from birds and mammals to other insects. However, since it is extremely difficult to examine the ways in which one insect defends itself against another, most study on insect defence has, so far, been concerned with how insects protect themselves against birds.

Hide-and-seek An insect's first line of defence is, quite simply, to hide. A large number of species do this by restricting their movements to the hours of darkness, when most birds cannot detect them; during the daytime they remain concealed, burrowing or creeping under debris and into crevices.

In order to see a number of flightless insects which move only at night and are seldom seen during the day, you may have to trap them. One easy way of doing this is to sink a jam jar into the soil in a broad-leaved wood or garden so that its rim is level with the ground surface. Leave this over night, and you should find it contains a number of flightless insects, particularly ground beetles–well-known nocturnal wanderers.

Flying insects are much easier to spot at night. Many night-flying moths hide during the day in long grass or under low-lying bushes, some of the more lightly built species (for instance the geometer moths) hiding in the foliage of trees and bushes. Butterflies which overwinter in the adult winged stage of their lives, such as the comma and the tortoiseshell, also hide among vegetation or in hollow trees and outhouses.

Cunning camouflage Although most of the insects already mentioned rely mainly on being under cover, and therefore out of sight,

they do exhibit some elementary stages of camouflage.

Insects living among the foliage of trees and bushes inhabit a world of green leaves threaded with brown twigs. A sample of these insects, shaken from a leafy branch on to a white sheet, will consist almost entirely of green or brown bugs and caterpillars–for instance, shield bugs, weevils and green oak roller caterpillars. Likewise a sample of invertebrates collected from the leaf litter will be predominantly black or brown. The reason for this is obvious–an insect which is effectively camouflaged in its environment has by far the best chances of survival.

The next stage in the elaboration of camouflage is the disruptive pattern. In military operations large, characteristically shaped objects, such as tanks and 'pill-boxes', are painted with large-scale irregular patterns of dark and light green, which break up and conceal their outlines. This principle is of more importance in concealing large animals, but it does occur in insects, and is usually combined with a resemblance to their specific background.

The oak beauty moth provides a good example of this, since its wings closely simulate the bark of oak trees (where it commonly rests) and it has a mottled band running right across its forewings which breaks up its telltale arrow-head shape.

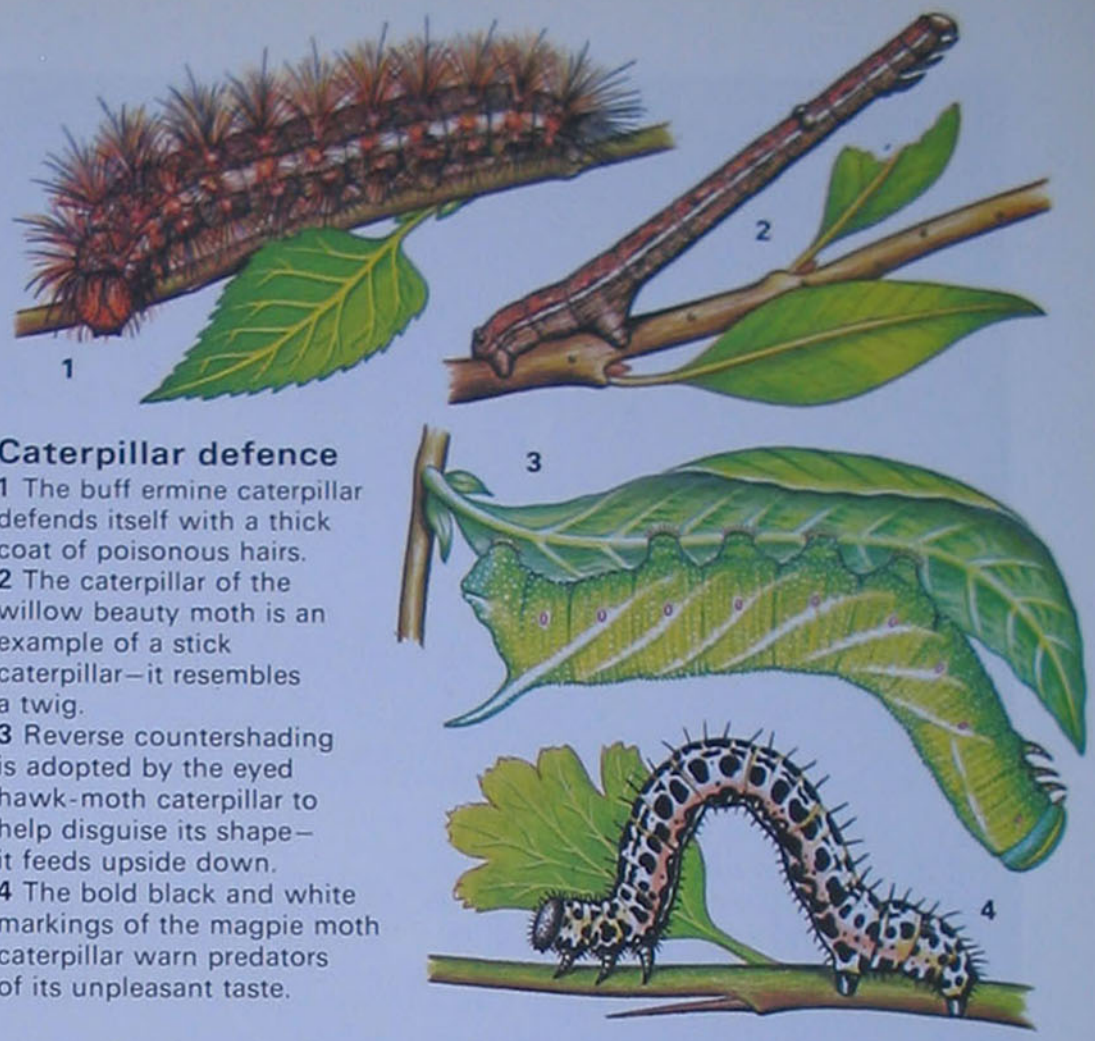
Another concealment principle seen in some of the larger caterpillars (the hawk-moth caterpillars, for instance) is that of countershading. Light, under natural conditions, comes mainly from above, and a rounded body tends to betray its shape when strongly lit above and shaded below. If, however, it is coloured dark above and pale below this effect is counteracted.

The caterpillar of the eyed hawk-moth is an interesting example of this countershading, being dark green underneath and light green on top. Since its normal resting position is upside-down, this 'reversed countershading' effectively conceals it.

Although butterflies and moths present a greater variety of camouflages than any other insects, they by no means have a monopoly. Some members of the Orthoptera are also protected by camouflage; bush crickets are green or brown according to whether they live mainly among foliage or on the ground, while grasshoppers frequently have a pattern of longitudinal brown and green streaks, well suited for concealment among grass stems.

Resting position Butterflies and moths add to their diversity of colour, pattern and shape, a variety of resting postures which makes them the foremost exponents of camouflage among all animals. When the comma butterfly is resting, particularly during its winter hibernation, it closes its wings in such a way that it resembles a withered leaf.

The lappet moth is adapted for concealment among dead leaves not only by its



Caterpillar defence
1 The buff ermine caterpillar defends itself with a thick coat of poisonous hairs.
2 The caterpillar of the willow beauty moth is an example of a stick caterpillar–it resembles a twig.
3 Reverse countershading is adopted by the eyed hawk-moth caterpillar to help disguise its shape–it feeds upside down.
4 The bold black and white markings of the magpie moth caterpillar warn predators of its unpleasant taste.

Above: In areas where exposed rock and stone walls are prominent features, moths–such as this small dusty wave–may be patterned to blend with the background as there is little cover for concealment.

Right: The flamboyantly coloured cinnabar moth may be attractive to our eyes, but for birds the bright red and black colouring warns of the moth's distasteful properties. These are acquired during the moth's larval stage, when the caterpillar feeds on ragwort–a plant containing toxic substances.

Left: Some harmless insects, such as the spectacular wasp-beetle (*Clytus arietis*), gain protection by resembling other species which have their own means of defence. This concept is known as mimicry – the genuinely harmful species (the wasp) is called the model, while the harmless deceiver is known as the mimic. The wasp-beetle, like all other wasp mimics, is active during the day, moving jerkily among flowers and foliage, such as the guelder rose shown here. Other wasp mimics in Britain include the hoverflies and clearwing moths.

reddish-brown colouring but also by its peculiar resting posture, in which it completely disguises its moth shape by bringing its hindwings forward so that they project beyond its forewings.

One of the most impressive kinds of camouflage is adopted by the so-called stick caterpillars of some geometer moths. Their bodies are coloured and patterned to resemble the twigs of the trees and bushes on which they feed, often even having humps on their backs to represent buds. When they are not walking or feeding, these caterpillars adopt a rigid pose, clasping a twig with their two pairs of abdominal feet so that they resemble growing twigs. The resemblance is so exact that it deceives our eyes – and presumably those of predators – almost totally.

Below: When resting, the buff-tip moth is extremely difficult to spot as it closely resembles a short piece of freshly broken stick. The thorax (in front) and the wing-tips (behind) are yellowish in colour, giving them the appearance of exposed wood, while the wings, which are rolled around the body to form a cylinder, are the greyish colour of tree bark. If you are searching for buff-tip moths, they occur in almost any habitat where trees are abundant.

Warning colours A number of brightly coloured insects, which make no attempt to hide or camouflage themselves, would appear to be sitting targets for hungry birds, yet somehow they manage to escape predation. To us, many of these insects appear beautiful, but the message their coloration conveys to predators is one of warning, for nearly all of them are distasteful or poisonous, and therefore inedible.

In dry open spaces, such as chalk downland and sand dunes, where there is little cover for concealment, brightly coloured burnet moths are often abundant, flying about and resting on flowers in the sunshine. Despite their conspicuousness, nearly all birds ignore them. If a young or inexperienced bird dares peck at a burnet, it immediately drops it and then exhibits signs of distress, salivating, and wiping its beak. It will never touch another burnet moth.

The body fluids of burnets are not only unpleasant in taste; they are also poisonous since they contain hydrocyanic acid and various histamine substances. This has a curious consequence – burnets are not affected by the insect collector's old-fashioned cyanide killing bottle since they are necessarily immune to the cyanide in their own bodies.

The magpie moth, a white species with black and yellow markings, is another common insect which displays warning coloration. Once a well-known entomologist was bold enough to taste specimens of this moth during its larval, pupal, and adult stages. Not surprisingly he found they all had a particularly bitter flavour.

Some species of caterpillar protect themselves with a coat of hairs, which may be extremely thick, as in the tiger and ermine moths, and poisonous as well. The hairs on the caterpillar of the brown-tail moth, for instance, are capable of causing a severe and

irritating rash on human skin.

Butterflies and moths are not the only insects which adopt these fearsome tactics. The bugs of the suborder Heteroptera (which includes shieldbugs) taste and smell extremely unpleasant–a fact you soon discover on handling them. Some, such as the well-known ladybirds (which secrete a vile-smelling liquid) and the rare black and red *Lygaeus equestris*, have warning colours, but many species are green and brown, appearing to use camouflage as a first line of defence, and inedibility as a second.

Wasp warnings Wasps display a striking warning coloration in the form of yellow and black stripes which inform potential predators of their capacity to sting. A rather unexpected feature of this is that, as well as being armed with a dangerous sting, they taste extremely unpleasant.

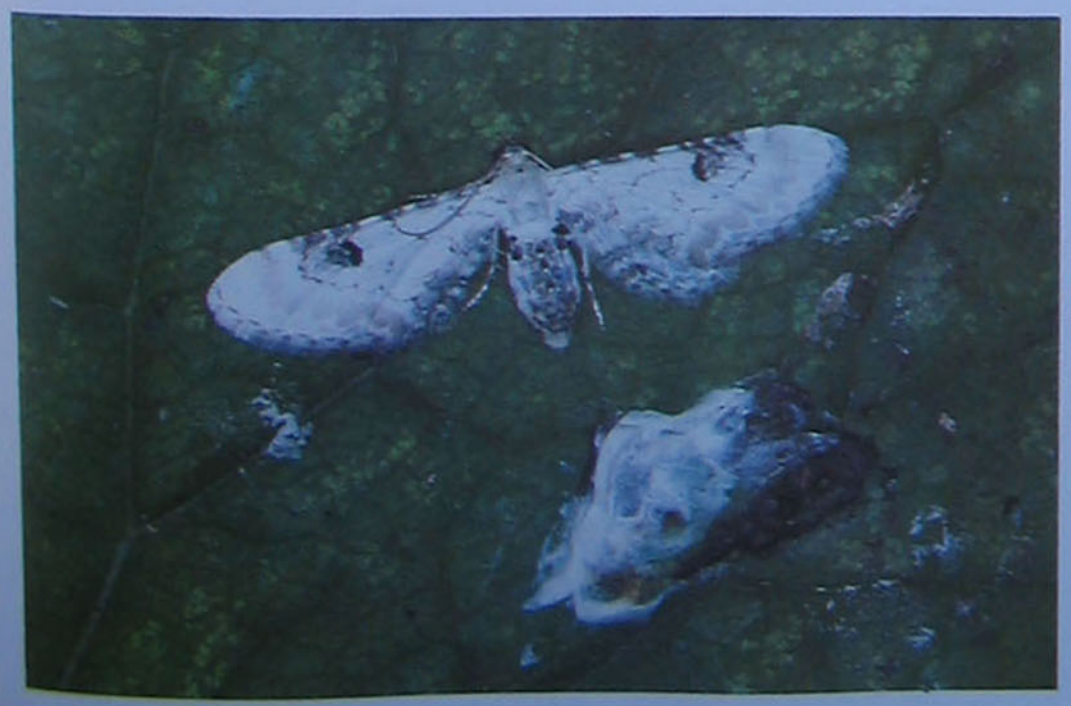
The distinctive colouring of wasps has come to be recognised by birds as a danger signal and wasps are therefore left well alone. This has led to the development of an extraordinary phenomenon in the insect world. A large variety of completely harmless insects have evolved markings and colours similar to those displayed by wasps. They gain a distinct protective advantage from this resemblance, which is known as insect mimicry.

In Britain the only obvious examples of mimicry are those insects (hover-flies, clearwing moths and the attractive wasp-beetle) that mimic wasps and hornets. In the tropics, however, complex associations also exist between distasteful and palatable butterflies, and between many other insects.

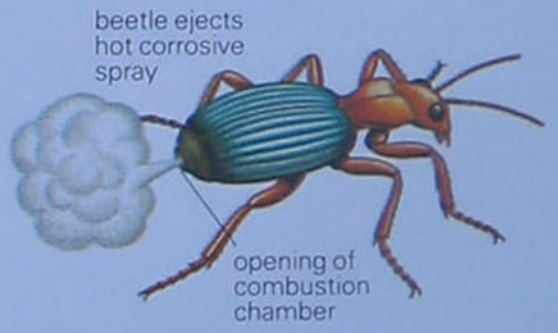
Curious colouring A minor curiosity of adaptive colouring is seen in some small moths and caterpillars, which rest on leaves and are coloured black and white so as to resemble bird droppings. Whether they are hiding, or are imitating something unpleasant, or using cryptic camouflage or mimicry, it is a most effective way to discourage hungry birds.

Above: Ladybirds exude an evil-smelling fluid which they advertise with their bright colours. They hibernate in swarms, maintaining a protective aura of ill-odour.

Below: The lime-speck pug moth is most effective in discouraging the attentions of birds–it resembles their droppings.



The bombardier's cannon



The bombardier beetle has the most remarkable defence mechanism, consisting of a series of minor explosions emitted from the beetle's rear. Chemical substances called hydroquinones and hydrogen peroxide are secreted into a 'reservoir' near the beetle's rear end, which opens into a 'combustion chamber'. When alarmed, the beetle passes the mixture into the combustion chamber, together with catalytic enzymes which cause the two substances to combine in a violent chemical reaction. This produces water, oxygen and highly caustic quinones, and at the same time enough heat to vaporise some of the liquid, so that the charge is blasted out as a boiling hot corrosive spray. Ten to twenty discharges may be produced, deterring even the most persistent predators.

WINTER: LIFE IN THE COLD SEASON

On a frosty day in mid-winter a sinister beauty etches the land, enbalming it in a hard glaze of ice. Although many plants have set seed and withered, and many animals have hibernated or migrated, there is still a surprising amount of activity in the countryside, especially on milder days.

In the British Isles it is hard to determine when winter truly begins yet, after the trees have shed the last of their leaves in mid-November, the change seems to jar. The richness of autumn is soon forgotten, and it becomes as difficult to recall vividly the soft green pelt of a woodland canopy as it is in June to imagine a leafless glade. In a sense this is a bonus; if our memories were more perfect, the drama of seasonal change would be much diluted.

Within the season of winter itself, the British Isles experiences a variety of climatic conditions, the result of its location between the Atlantic to the west and the Continent of Europe to the east. Constant waves of deep Atlantic depressions force chill moist air over the countryside, bringing with it icy rain, sleet and snow. This pattern is most evident in December, often the stormiest month of winter. In January and February high pressure over northern Europe often gains ascendancy and, while it fends off the Atlantic onslaught, it clamps a pall of still-freezing air over the British Isles. The sea is now at its coolest; the sun's meagre warmth is rapidly lost to clear blue skies, and temperatures typically hover around zero all day.

Our severest winters are generally associated with such high pressure located above the polar regions. In the record-breaking winter of 1981-2, temperatures plunged to extreme lows, reaching minus 20-25°C (−4-13°F) overnight. The depressions which penetrated this frozen still-life from time to time disgorged heavy falls of snow and drifted it into deep scalloped waves wherever obstacles arrested the force of the wind. Such conditions greatly stretched the survival capabilities of wildlife.

In these extreme winters shrubs, and trees such as the holm oak and Sequoia redwoods introduced from warmer climes, suffer badly. Our native trees, evolved to withstand such conditions, also wilt, but less so. As they shed their leaves, they turn to a state of virtual hibernation. Blizzards may blow harmlessly through the bare wood – if the trees retained their leafy canopy they would crack and topple under the dead weight of entrapped snow. Conifers evade winter's bite by evolving needle-like leaves which minimise the surface area through which vital moisture, hard won from the cold ground, would otherwise be lost. In addition, each needle is sheathed in a thick waxy cuticle which protects against pinching frosts. The conical shape of many conifers helps them further by shrugging off heavy accumulations of snow.

The foliage of trees is such a gift of shelter

and food in summer that it is hard to imagine any species profiting by its loss in winter. The bare limbs of trees, however, bathed in moisture and wan sunlight, provide ideal conditions for the lowly single-celled alga *Pleurococcus*, which now spreads upwards, dusting trunks and branches with a thin emerald sheen. These limitless vertical pastures are welcome food for herbivorous invertebrates– notably woodlice and millipedes, which are active through the winter months. They ascend the trees, mainly by night, to scrape a living from the rich algal bloom on the bark. *Pleurococcus* thrives best on deciduous trees, shunning the more acidic surface of conifers and also birches, which is why this species retains its silvery white gloss all year.

The remarkable survival powers of some other insects are equally evident in the depths of winter. Wherever the shelter of a hedge or wall offers a haven of still air, especially if it is warmed by a shaft of sunlight, swarms of winter gnats dance in apparently perpetual motion. The jigging clouds, comprised entirely of males, are curiously conspicuous, which serves them well, for the purpose of this communal aerial display is to attract females with which the dancers can mate.

The winter moth also chooses the grimmest season to mate and lay eggs. Scientists have noted about six females to every square metre of oak canopy. Each insect lays about 150 eggs, so paving the way for a mass emergence of defoliating caterpillars in the spring. Many adults are snapped up by hard-pressed tits in the cold light of dawn, but with their eggs safely jettisoned, the moths have ensured the survival of the next generation.

Most insects, however, lie dormant, buried in whatever nook or cranny offers them the best protection from cold and predators. Many moths and butterflies overwinter as pupae, though some adults, such as those of the brimstone and tortoiseshell butterflies, also overwinter successfully. The key to the survival of many so-called 'cold hardy' insects lies in the conversion of blood sugar to glycerol which acts as a dilute anti-freeze, protecting vital tissues against prolonged sub-zero temperatures.

Some animals of the cold north, notably the Soay sheep on St Kilda, are thought to find a different source of anti-freeze by eating more moss in winter. Many mosses are rich in fatty acids which, when absorbed, may help to keep limb joints mobile in low temperatures. This may explain why the reindeer, a herd of which is now well established in the Cairngorms, paws laboriously at the snow crust to expose moss, even though it provides little in the way of actual food.

Equally ingenious adaptations are shown by such hibernating mammals as hedgehogs, dormice and bats. The surplus food they so feverishly gather and devour in autumn is converted into a thick layer of brown fat which produces a third as much energy per gram as normal body fat. To enable it to tap this source slowly through the winter, the hedgehog drastically reduces its heartbeat and breathing rate, so that up to 15 minutes may elapse between successive breaths. Simultaneously its blood thins to prevent clotting and its body temperature drops to near that of its surroundings. If the hedgehog becomes too cold, it automatically shivers to generate a little extra heat. A mild spell in mid-winter can prove fatal, spurring hibernators into energy-sapping activity and leaving them with depleted fat stores if freezing conditions suddenly return.

Others cope better with fluctuating temperatures. A mild day coaxes out some bats, no doubt to the detriment of any flying insects. Badgers are exceptionally hardy and readily emerge from semi-hibernation on warmer days.

Deep snow, however, is a major hazard for those mammals, active all winter, who may have to travel further afield for food, so burning up valuable body reserves. Scottish red deer ultimately abandon snowbound hills to graze on lowland pastures, while roe deer demolish bramble thickets and strip the bark of saplings wholesale. Small mammals such

as voles and shrews are better off, mining tunnels under the snow to escape the hostile conditions above.

The covert existence of small mammals in winter also affords them protection against such predators as foxes and weasels which stay active throughout the year. In Scotland, however, the stoat regains some of the advantage by moulting into a white coat in winter, adding the weapon of camouflage to its hunting strategy. Prey species such as the mountain hare and ptarmigan likewise abandon their brown summer coat for a white one and so make themselves less conspicuous to stoats and other hunters, notably the golden eagle.

Birds are especially vulnerable to the famine conditions imposed by a blanket of snow and ice. In harsh weather red grouse have been seen entering farmyards to pilfer chicken-feed; curlews and water rails–normally among the wariest of birds–venture into gardens, and even snipe have been seen at bird tables.

Although it occasionally freezes over in the hardest winters, the coast is usually an invaluable refuge for many birds we typically associate with inland haunts. Freshwater birds such as herons and kingfishers are often seen by the shore in winter, especially when rivers and streams are icebound. Kingfishers adapt remarkably well, plunging into rock pools in search of small fish and crustaceans.

Indeed, birds travel vast distances to escape inhospitable conditions. Normally quite sedentary birds of all kinds may join in spontaneous 'hard-weather movements', roving widely around Europe in spectacular flocks. First to move are often the lapwings, skylarks, redwings and fieldfares. Radar studies have shown that if severe conditions alternate between the British Isles and Europe, lapwings often commute back and forth across the Channel several times each winter. Some winters also bring exotic immigrants, notably waxwings and crossbills when their native Scandinavian food crops fail to support them.

The short winter days give birds little time in which to meet their food requirements. It then becomes vital to conserve as much energy as possible during the long, cold over-night vigil. Small birds are especially vulnerable to heat loss at night, and some, such as wrens and long-tailed tits, huddle together in groups to share body warmth in a snug recess, such as a tree hole or old nest.

Some species, however, breed so early in the year that winter is a time of intense advance preparations. Male tawny owls stake out their breeding territories in November, proclaiming ownership with their familiar hooting call. By December pairs are firmly established in their own domains, and the male begins courtship-feeding of the female, principally offering her voles and mice. By late February or March the female will be fortified for egg-laying and the role of incubation which she alone performs for upwards of a month.

Another famous early nester is the golden eagle which not uncommonly incubates its eggs stoically in a snowbound mountain eyrie in March. While seasonal fluctuations in their prey favour late winter nesting in these two raptors, it is close association with man-made food supplies that enables the diminutive collared dove to nest, albeit in small numbers, throughout the winter months.

As spring draws near we traditionally look to the plant kingdom for more obvious signs of stirring activity. Few plants are equipped to flower or fruit in winter, although gorse may flaunt the odd bloom in December, and the winter-toadstool, 'velvet shanks', with its dense clusters of yellow caps, adds welcome colour to bare deciduous woodland. Even by January, however, there is a gentle but perceptible quickening of pace; the blooms of snowdrops and winter aconites emerge, looking all the bolder for their pallid fragility. In sheltered corners of woodland, elder slowly uncurls its first leaves, and hazel extends its pollen-laden catkins to the first drowsy flying insects, while high in the bare treetops a mistle thrush practises its song for spring.

WANDERING MARINE TURTLES

Marine turtles occur as rare vagrants on our coasts: barely a handful arrive each year, straying far from their habitats in warmer seas.

Marine or sea turtles belong, with the tortoises and terrapins, to a group of reptiles known as chelonians. Tortoises (confusingly called turtles in America) are land-dwelling chelonians, while terrapins are semi-aquatic freshwater animals and marine turtles spend almost their entire life at sea.

Marine turtles are well adapted to their habitat. They are superb swimmers, the graceful movements of their flippers enabling them to move through the water swiftly, in marked contrast to the slow walk of tortoises.

Female turtles go ashore to lay their eggs, but this does not occur in temperate countries such as Britain and Ireland. Marine turtles have an annual cycle of activity, some migrating vast distances to reach favourite nesting beaches; there they crawl up the beach, dig nests in the sand and lay their eggs.

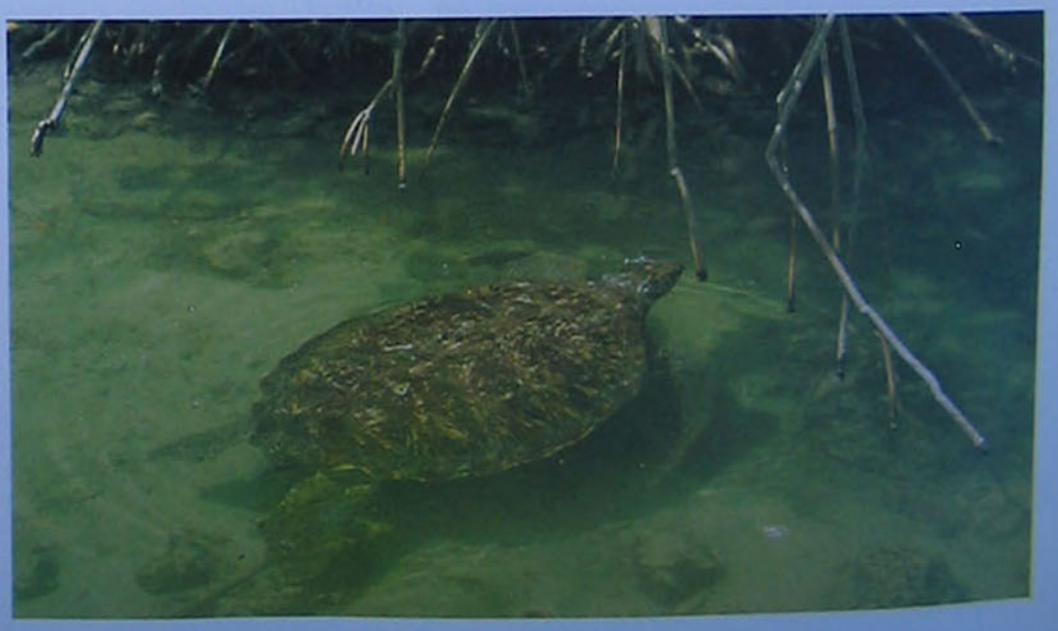
There are seven species of marine turtles worldwide, and five of these are sometimes seen swimming close offshore or stranded on British beaches. For the turtle concerned, this is in all cases a misfortune, for the animal is a vagrant, diverted from its usual course in warmer waters by storms or unusually strong sea currents. The vagrant is unlikely to find its way back to its normal habitat, and will probably die because it is not suited to our cold temperate conditions. Sometimes the carcase of a marine turtle is washed up on the strandline.

The leatherback turtle The leatherback, the larger of two species from the Mediterranean

Above: The green turtle, one of the tropical turtles that are seen on rare occasions on British and Irish coasts. It is normally found in Latin American, African and Asian waters.

Right: The vividly coloured head of the green turtle. The chequered pattern may serve as camouflage, blending with the background of sea grasses among which the turtle often feeds.

Below: The hawksbill is also a tropical species.



and subtropical waters, is found relatively often in British waters. It has been seen as far north as Shetland and the Norwegian sea, but usually it appears around the south and west coasts of England and Ireland. The leatherback's shell can be up to 1.9m (6ft) in length, and is not likely to be confused with that of any other species of turtle, for it is made up of small bony plates covered with a leathery skin–instead of the smooth, hard plates characteristic of other marine turtles. In addition, there are several prominent ridges running the full length of the carapace. In general, the leatherback is dark brown or black, with small spots of white or yellow particularly noticeable on the young animals.

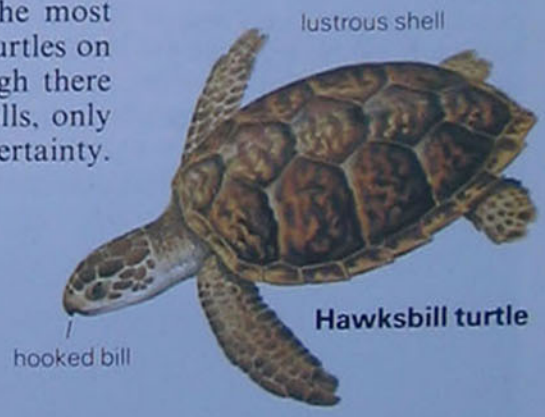
The loggerhead turtle This is the smaller of the two species usually sighted, having a carapace up to about 1m (3ft) in length. The carapace is horny and consists of several regularly arranged plates. The loggerhead tends to be reddish-brown or olive on the carapace, and somewhat yellowish underneath. Algae, barnacles and other small marine creatures often grow on its shell, and this results in considerable variation in colour.

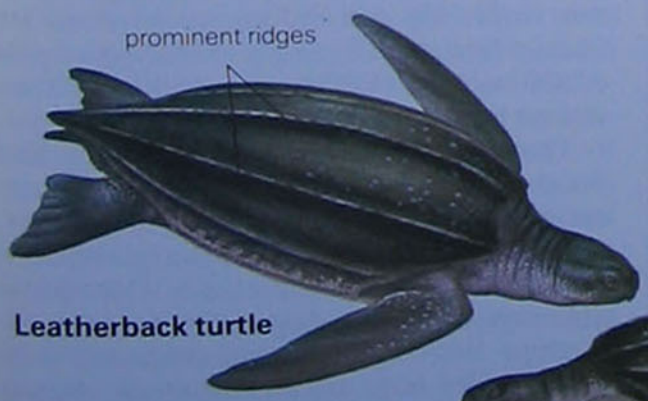
Rarer visitors Three tropical species of marine turtle are found around our coasts, but sightings have been very few indeed. The smallest is the Kemp's Ridley turtle, which has a shell no longer than 65cm (a little over 2ft); the plates are blackish and grey or olive coloured. The hawksbill turtle, about 90cm (3ft) in length, is largely brown with darker markings. The shiny substance of its carapace was used for making ornaments, combs and spectacle frames. Today, trade in turtle products is banned in many countries, including Britain and Ireland. The name of the species refers to the prominent hooked beak on the snout. The third tropical species is the green turtle, which is usually brown or olive, with darker markings. Green turtles grow to about 1.4m (4½ft) in length.

Above: A hawksbill surfaces for air. The 'bill' is a modification used for hooking crabs and other small animals out of crevices in coral and rocks. The bill is particularly useful during the early years of the turtle's life, for at this time the species is wholly carnivorous. On reaching maturity, it becomes omnivorous, eating grasses and seaweeds as well as small marine animals.

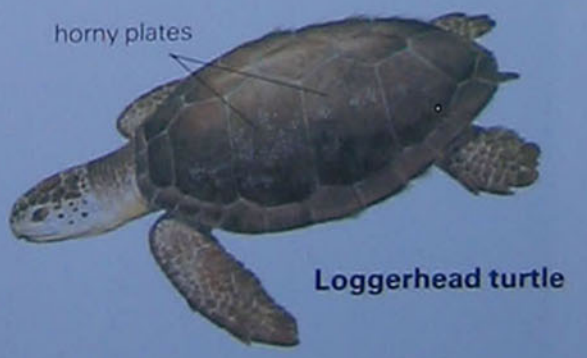
Infrequent records At best, only a handful of turtles arrive in our coastal waters each year. Of these the leatherback is the most frequent. Even so, only about two turtles on average are seen each year. Although there are a number of records of hawksbills, only one (in 1953) was identified with certainty.

Right: The hawksbill has a shiny carapace which is largely brown with darker markings. It is the largest of the tropical turtles to be found in British waters, growing to a size of 90cm (3ft).
Note: These illustrations are not to scale. When fully grown, the loggerhead is a few inches longer than the hawksbill, but the leatherback grows to twice the hawksbill's length.





Above and right: The leatherback has a distinct appearance because of its leathery skin and its prominent dorsal ridges.



Above: The loggerhead has a horny, reddish-brown carapace; sometimes it is olive-coloured. The underside is yellowish.

BRITAIN'S VARIED VALLEY BOGS

Although the most extensive areas of bog are to be found in the wild, remote uplands of Britain, parts of the drier, gentler south – Surrey's Thursley Common, for instance, or the New Forest – also have bogs, in particular the type known as 'valley' bog.

Opposite right: The formation of valley bogs, as their name suggests, depends mainly on terrain. Where water collects along a valley, conditions are right for peat formation, provided the flow is fairly sluggish or impeded at times. This proviso still allows a wide variety of conditions to occur in valley bogs, with the result that they are, perhaps, the most variable of all our types of bog. Unlike raised and blanket bogs, valley bogs do not rely purely on rainfall and are therefore not restricted to north and west Britain.

Below: The central water-course of a valley bog may be picked out by a line of the strangely shaped hummocks of tussock sedge.

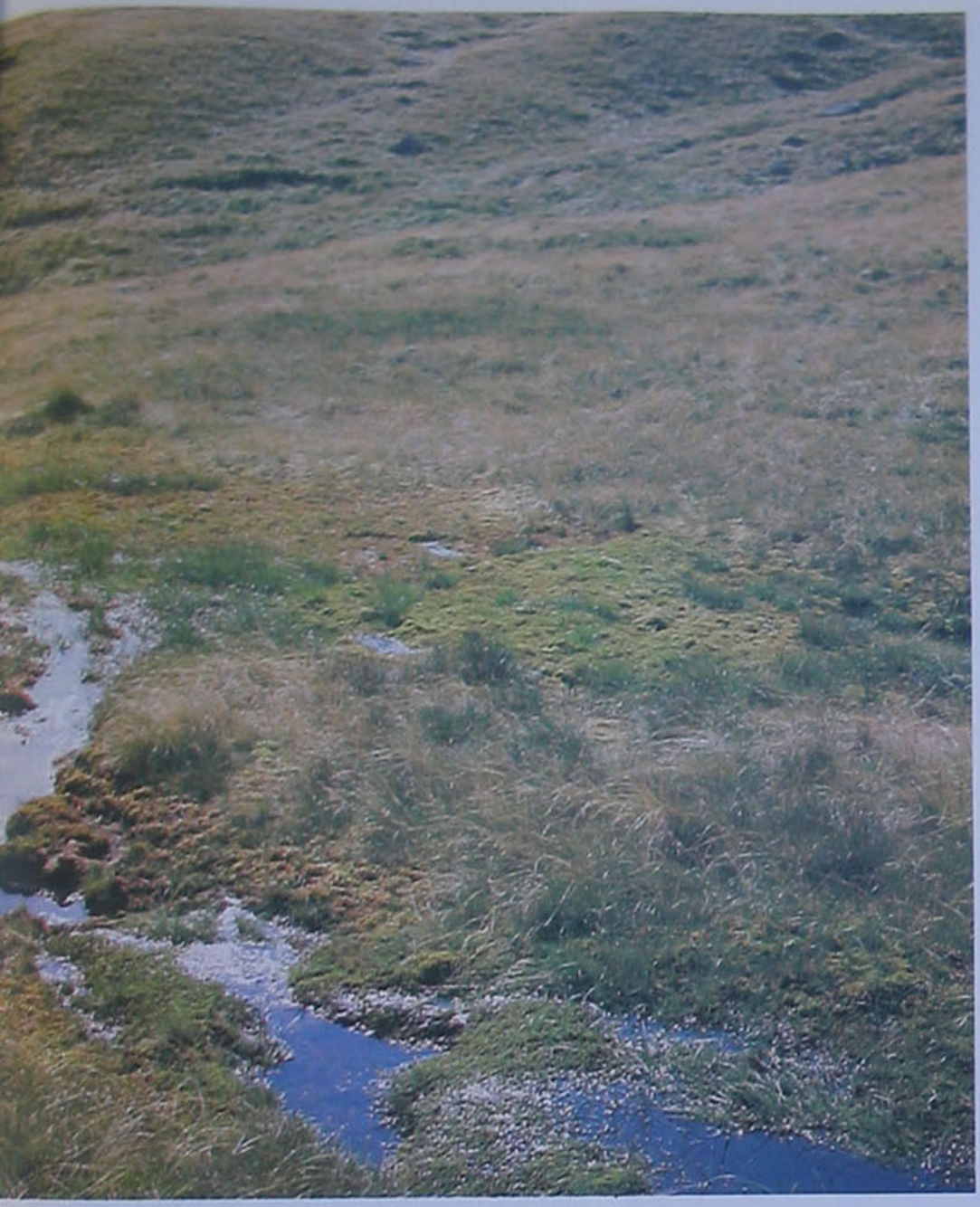
While the high rainfall and cool climate of the north and west of the British Isles give rise to our most widespread development of raised and blanket bogs, you can also find something of the untamed, primeval atmosphere of these places in parts of southern Britain. However, while the blanket bogs of upland Britain are entirely dependent upon rainfall for their formation, the bogs of the south are a product of both climate and topography, and are therefore not restricted solely to the wetter parts of the country. Thursley Common National Nature Reserve in Surrey and the bogs of the New Forest in Hampshire are examples of just such southern bogs, of a type known as valley bog. (Visitors to Thursley Common, for their own safety, are advised to follow the clearly defined series of track-ways constructed by the NCC.)

At its simplest, a valley bog is formed when water collecting along a valley induces peat to flourish. In practice, this concept is much more complex; nevertheless, this very complexity tends to produce a much wider range of conditions than is possible among the simpler blanket and raised bog systems. Consequently, valley bogs are possibly our most varied and widespread type of bog.

Valley bogs vary in size from small seepage lines only a few metres wide to huge systems several miles long and a mile or so wide. However, the huge flood-plain mires which represent the upper range of valley bogs are generally regarded as a type of bog in their own right. By convention, valley bogs are usually fairly small – rarely exceeding an area of 500 hectares (1235 acres) – and are characterised by a central watercourse.

The distinction between valley bog and flood-plain mire is that the central water-course of the latter tends to be a major river, whereas in a valley bog the water-course is never more than a small stream. This feature also separates valley bogs from the fen reed-swamps that occur around the margins of lakes – valley bogs are formed where there is moving water, lake reedswamps where the water is static.

Topography and water sources For valley bog formation, a valley is obviously the first requirement, but its shape is also extremely



important. Peat formation is encouraged by sluggish or impeded water movement, so a steep valley with a tumbling mountain torrent offers little possibility of bog development, whereas a broad, gently sloping valley provides ideal conditions. Blanket and raised bogs occur in a fairly simple set of climatic conditions, but for valley bogs the conditions vary with such factors as the permeability and nutrient status of the bedrock and the size of the catchment area.

The final nature of the individual bog depends on the interactions between these various elements, but by far the most important factor is the nutrient status of the various water sources. There are three sources of water: rainfall, the valley sides and the central water-course. The first two are often not immediately apparent or easily determined, particularly if the valley is shallow and with a barely perceptible slope, but the flow rate and nutrient status of the central water-course is more easily established.

How a valley bog develops Peat formation – the accumulation of dead plant material – occurs because constant waterlogging prevents the normal processes of bacterial decay (the most efficient bacteria are those that need oxygen). Although the constant flow of water provides a certain level of oxygenation, it is insufficient to bring about complete decomposition of the year's plant growth before the next growing season. The build-up of this undecomposed material (as peat) results in the release of humic acids which further inhibit decomposition.

However, balanced against this is the nutrient content of the water flowing through the system. If it is rich in minerals, these counteract the acidification process and allow a certain amount of decomposition to continue. When the nutrient levels are low and conditions are markedly acidic (pH4-pH5), the peat formed is moss peat – consisting of the remains of the bog moss *Sphagnum*. Somewhat richer conditions (pH6-pH8) encourage a sedge-dominated community which gives rise to a rather amorphous type of peat known as fen peat. Although in general sphagnum peats form the deepest deposits, even the richest fen peats can result in depths of up to 5m (16ft), and it is quite common to find a long history of peat-cutting for fuel over such areas. Indeed, a Government Report of 1789 concerned with the management of the New Forest states: '. . . those who make a trade of cutting turf and peat, for sale, are becoming so daring as to threaten the burning of the Forest if they are interrupted.'

Plants of the central water-track Looked at in cross-section, a valley bog can be seen to consist of distinct zones, which reflect the three separate sources of water flowing into the site. In the centre is the water-track, which may be a broad stream or no more than a seepage line. It is usually the zone with the highest levels of oxygen and is often the richest part of the site, unless the flow is particularly sluggish and the water has been forced to percolate along a sphagnum-rich seepage line.

Under conditions of faster flow, the central water-course is often picked out by a line of alder and willow trees, the latter occurring

Below: Water from the sides of a valley bog tends to be fairly nutrient-rich; the plant community here is dominated by herbs, among them this beautiful insectivorous butterwort.

Above: A plant species sometimes found growing near the central water-course of valley bogs, the marsh cinquefoil can be recognised by its reddish-purple petals framed by wider, longer sepals. It can reach as much as 45cm (18in) in height and prefers fairly acidic conditions.

particularly where the water is nutrient-poor. Under slightly richer conditions it is common to find the large humpy tussocks of the greater tussock sedge flourishing along the water-course and dominating the areas of regular inundation. Under rather poorer conditions, however, the water-track is clearly picked out by the small shrubby sweet gale which gives off a heady scent whenever the leaves or buds are slightly bruised.

Where the flow is reduced to little more than a seepage, but is nevertheless mineral-rich, a carpet of so-called 'brown mosses' dominates the zone of water movement. This more open community consists of such mosses as the bright yellow *Philonotis fontanum*, the golden, star-like *Campylium stellatum*, the strange claw-shaped *Scorpidium scorpioides* and the robust *Acrocladium cuspidatum*, all of which form dense mats within which such species as mud sedge, black bog rush and bog pondweed are found. Also to be seen here are the delicate white flowers of grass of Parnassus and the strange pink flowers of the marsh cinquefoil, as well as the insectivorous common butterwort and the bladderwort.

Other plants Away from the immediate effects of the water-track, conditions generally become more acidic. Small nuclei of sphagnum moss hummocks rise above the water table to become largely rain-fed, and such species as common sundew, bog asphodel and cross-leaved heath dominate the vegetation.

Such an association clearly demonstrates that the most important source of water for this zone is rainfall, although the presence of other species, such as bottle sedge, bog pimpernel, marsh pennywort and marsh arrowgrass, scattered within this zone, highlight the fact that even here water flow from the surrounding slopes plays a significant part in shaping the structure of the community.

The outer zones, fed by run-off from the surrounding slopes, depend almost entirely on the nature of their soils. Where these are rich, a limited form of 'brown moss' community grades into a wet-meadow type of vegetation which is often extremely rich in herb species, although it is unusual for this part of the bog system to have survived intact because it is so easily drained. Where water forms in ponds at the foot of the steep valley slopes, a not uncommon sight is a fringe of alder, willow and common reed, or – particularly where there has been a certain amount of agricultural enrichment – stands of reed-mace.

Birds and insects From the north of Shetland to the south of England perhaps the most characteristic bird of the valley bog habitat is the snipe. Nothing is more guaranteed to shatter the quiet of an early morning walk across a valley bog than the explosive launch of a startled snipe from beneath your feet. Like a little brown bullet the snipe streaks away on a whirr of wings, uttering a short sharp cry of alarm, then jinks left and right

Below: Another plant to look for in valley bogs is the attractive grass of Parnassus – not a grass at all but a white-flowered herb. It reaches 10-30cm (4-12in) in height.

Below: Typical vegetation of the more nutrient-rich parts of valley bogs. Species visible here include bog pimpernel, marsh pennywort and water dropwort. They show up as bright green areas among the brown of the sphagnum moss.

at high speed before diving to the ground behind a convenient tussock. In the evening the same bird can be heard 'drumming' as it circles around its territory. Climbing a couple of hundred feet, it dives to the ground, extending two stiff tail feathers which vibrate in the rushing air. The sound is almost a bleat, like the cry of a distant lamb, and blends perfectly with the other sounds of the evening.

Less ethereal than the sound of the snipe is the sharp scolding of the redshank, another bird sometimes found in southern valley bogs (although more particularly a bird of the north). With its bright red legs it perches on a convenient fence post and chatters away in an indignant manner to anyone approaching its territory. Like the snipe's young, the redshank chicks can run as soon as they hatch, but the raucous chattering of the parent birds causes them to lie still, allowing their efficient camouflage to blend with the tangle of sedges and dwarf shrubs.

Both redshank and snipe are waders, equipped with long bills to probe the peat for insects, of which there are a great many, particularly in the southern valley bogs. Here an abundance of water combines with warm summers to provide a habitat for some of our rarest and most spectacular insects.

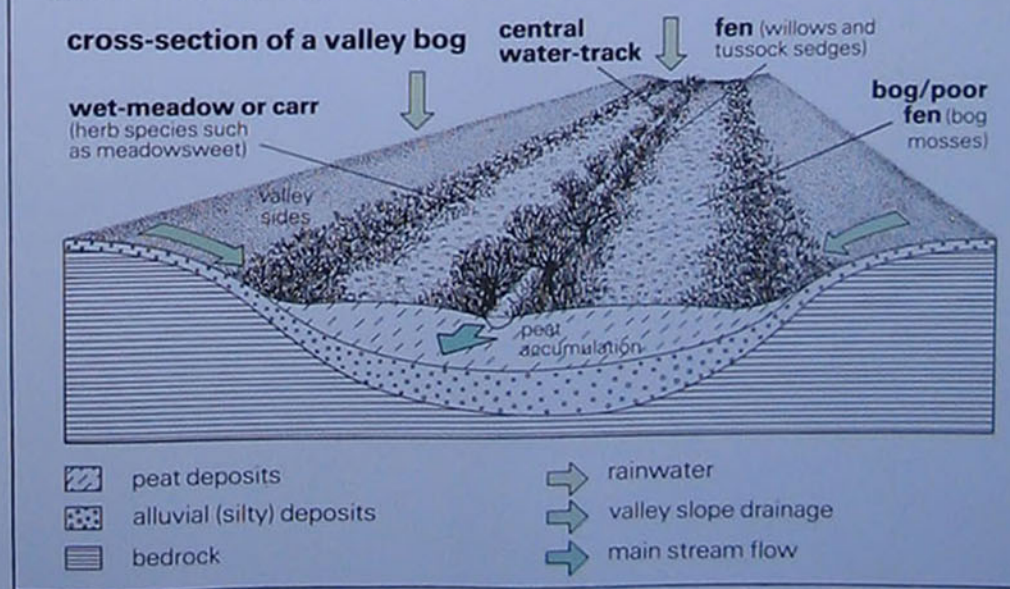
Extreme rarities, such as the dragonflies *Leucorrhina dubia* and *Ceriagrion tenellum*, tangle with the commoner libellulas and aeshnas, swooping and hawking over the areas of open water. However, they themselves fall prey to yet another rare and spectacular species–the hobby. Attracted by the ready source of insect food, this acrobatic bird can often be seen performing tumbling cartwheels through the sky while chasing dragonflies, or even swifts and swallows–birds also attracted by the rich insect life of our valley bogs.

Above: Typical valley bog topography. Three main sources of water feed the bog–the central water-track, the sloping valley sides and rainfall–but the formation of the bog also depends on rate of water movement, the nutrient status of the water, flooding frequency and the size of the catchment area.

Left: The raft spider–our largest species–may be found among the sphagnum mosses of a valley bog.

Formation of a valley bog

Peat formation in valley bogs occurs as a result of waterlogging. The type of peat may be moss peat in nutrient-poor conditions or, in richer waters, fen peat. In both cases peat depths of 10m (33ft) or more can occur. Different plant communities may develop in different parts of the bog, depending on nutrient flow and level of water.



WINTER VISITING THRUSHES

Of our six species of thrush, two are mainly winter visitors – the redwing and fieldfare. Their chief breeding grounds are in Scandinavia and Siberia.

Above: A fieldfare in a thicket. Migrant fieldfares begin to arrive in Britain in autumn, as soon as the weather turns cold in Scandinavia. They may arrive as early as September, but migration may continue as late as December. Often they continue westwards, and some reach Ireland.

No matter where you are in rural Britain, if you are out of doors on a calm, clear autumn night you are likely to hear, high overhead, the sounds of the winter visiting thrushes as they arrive: either a thin 'seep' or a dry, throaty chuckling call. These visitors are the redwing and the fieldfare (most of our breeding thrushes belong to four species: the song and mistle thrushes, the ring ouzel and the blackbird).

These thrushes begin their migration in Scandinavia or further east in northern Siberia. They fly along the European coast of the North Sea until they reach the Netherlands. From here a proportion cross the sea to England. Smaller numbers make the long crossing direct from Scandinavia to northern England and Scotland. The birds set off at dusk. If conditions are calm, those flying to southern England arrive well before midnight; those coming direct from Scandinavia make their landfall in the small hours or even at dawn.

If there is a full moon, it is possible to see these birds by looking through binoculars at the moon. Any birds that pass before the white face of the moon are clearly visible as silhouettes. From the numbers seen in this way, birdwatchers estimate the volume of migration at different times and on different nights.

The redwing The 'seep' sound is the commonest flight call of the redwing. This bird is fractionally smaller than the song thrush, which has a similar call. Some song thrushes from the Continent join our resident song thrushes for the winter, and so it is necessary

Left: Redwings experience difficulty in finding enough to eat during snowy periods. Here they feed on some rotten pears that have been left out for them.

to distinguish the redwing from this species. With a little practice you can tell the calls apart: that of the song thrush is a rather sharper 'tsip'.

These two birds even look similar. If you see the birds in flight, a glimpse of the redwing's rich russet-red underwing makes its identity clear, for the song thrush's underwing is a pale sandy beige. If you see the birds on the ground in daytime, there are some more obvious differences. In winter, song thrushes are usually seen in ones and twos, rarely far away from the nearest bushes, whereas redwings tend to occur in flocks, often widely scattered, over open grassland and fields. The redwing always has a darker back than the song thrush–particularly the race *coburni* which breeds in Iceland and winters in Scotland, occasionally straying further south. More important, a fringe of russet is visible where wing and flanks meet. Just as characteristic is the redwing's bold eyestripe, which is either white or yellowish-white.

Unusual migration pattern The vast majority of redwings seen in Britain and Ireland are spotted during the winter months, and are mostly migrants from Scandinavia and further east, where they breed in the northern pine forests, the birch woods and the stunted willow scrub as far north as the fringe of the Arctic tundra. Their pattern of migration is a most unusual one, for birds seen (say) in Britain in one winter may spend the next winter in southern Europe, and vice versa. In some years the numbers leaving Scandinavia are vast, and for a few days or weeks in autumn eastern Britain may seem full of redwings dotted across every suitable damp grassy field, until they gradually disperse to the West Country and Ireland.

As the smallest of the true thrushes, redwings suffer severely in cold winters, and any prolonged snowfall results in large numbers of underweight redwings struggling to find enough food to keep warm and stay alive.

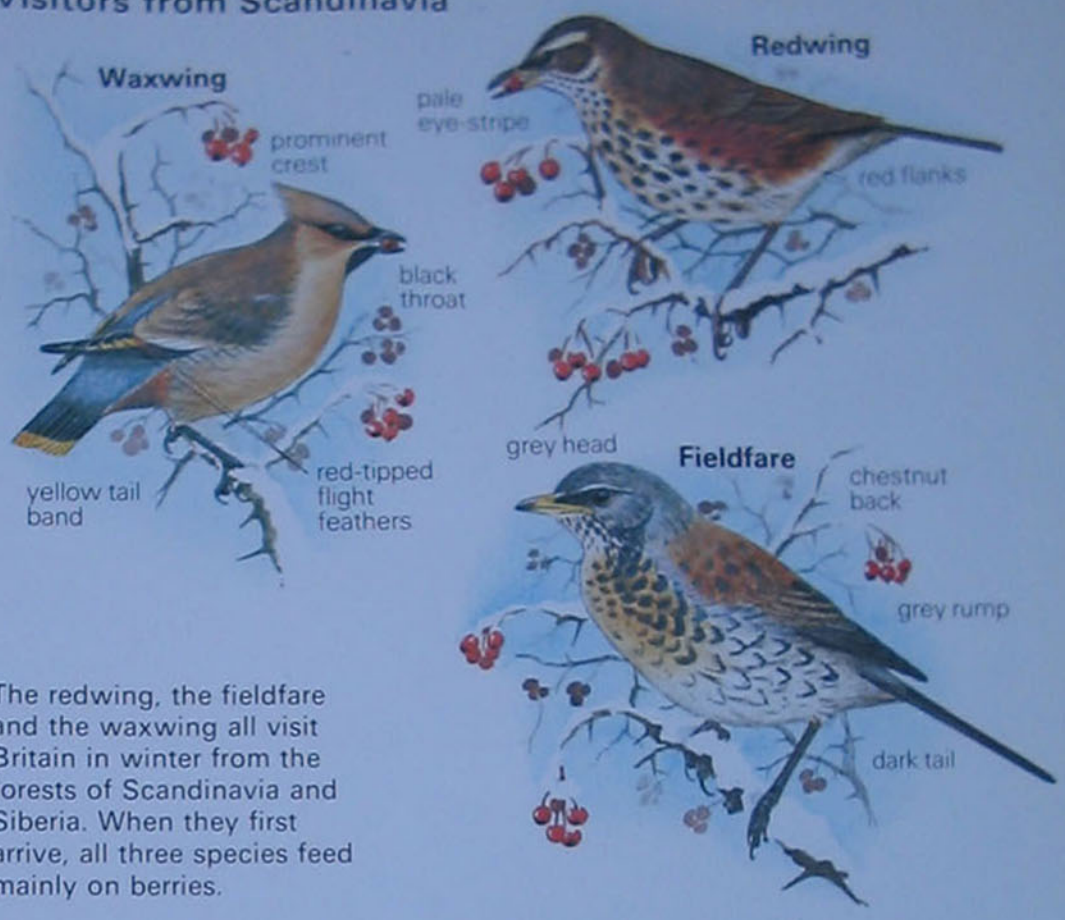
Redwings breeding in Britain It may be that our breeding population of redwings owes its origin to one, or several, of these huge autumn influxes of Scandinavian birds, but an alternative theory suggests that they originated from the returning spring migration of birds that had wintered in southern Europe. Some of these redwings may have been blown off-course to the west, settling where they found a suitable habitat.

The first proven breeding was in Scotland in 1925; sporadic attempts continued until a big increase occurred in the mid-1960s; in 1968 there were 20 pairs in Wester Ross alone. Most of the British breeding stock, probably now several hundred pairs strong, is to be found in northern Scotland. Their choice of habitats is wide, including birch and oak woodland, birch and willow scrub, alder carrs and lines of alders along streams, and the shrubberies of houses with large gardens. Elsewhere in Britain, a few pairs breed in the Border Country, and others, astonishingly, as far south as eastern Kent.

The nest has much the same appearance as that of a song thrush, built of coarse grasses with a mud core. Unlike the song thrush, the redwing puts an inner lining of fine grasses within the mud cup.

The fieldfare This is a much larger bird than the redwing–more likely to be confused, at a distance, with the mistle thrush, especially as both present a long-tailed appearance in flight. A closer view, however, reveals the true beauty of the fieldfare's plumage. A grey hood extends to a rich russet back, which in turn leads to a pure grey rump. The tail is black. In flight or perching overhead, the fieldfare

Visitors from Scandinavia



The redwing, the fieldfare and the waxwing all visit Britain in winter from the forests of Scandinavia and Siberia. When they first arrive, all three species feed mainly on berries.

Fieldfare (*Turdus pilaris*): winter visitor; a few pairs breed in Scotland and England. European range expanding. Sexes alike. Length 25cm (10in).

Redwing (*Turdus iliacus*): winter visitor; small population of a few hundred breeding in Scotland. European range expanding. Sexes alike. 21cm (8¼in).

Below: A redwing on its nest. Nesting begins in May, and there are normally two broods each summer.

Above: A fieldfare disturbed while feeding among a rich crop of berries. This photograph was taken early in the autumn, before the main plundering of the berry crop by such birds as redwings, fieldfares, song thrushes and mistle thrushes.

Left: A redwing fluffs out its feathers to keep warm on a winter's day. Any spell of cold weather may bring fresh hordes into Britain from across the North Sea; or the cold may cause those already here to migrate further westwards, in search of slightly warmer conditions.

reveals that its breast is cinnamon coloured, with dark brown spots, fading to white on the belly.

Even more characteristic than its plumage is the fieldfare's cackling laugh of a call: an easily remembered phrase even for those with a poor ear for bird voices. The summer song is less distinctive and not in keeping with the general musical quality of thrush family songs: a harsh, poorly formed jangle of notes.

Spreading south In Europe the fieldfare is a bird of northern forests with a distribution closely similar to that of the redwing, stretching as far east as Siberia. In Scandinavia, from whence most of our migrant fieldfares come, they nest in farmland, open woodland and even in suburban parks and gardens. For more than a century the fieldfare has been extending its range slowly westwards and southwards. When the birds reached Denmark their new colony expanded rapidly; but the same has not happened with the small British population (to date). The first British breeding pair was reported in Orkney in 1967, with further pairs in Shetland in 1968. They now breed on the Scottish mainland in a number of localities, and in England as far south as Derbyshire and Staffordshire, but the annual breeding total remains extremely small–perhaps ten pairs or less.

Fieldfare breeding season The fieldfare builds a nest similar to that of the mistle thrush. It is often sited in a tree fork, but in northern areas, where suitable trees or bushes are absent, it is situated on the ground. A foundation of thick dry grass stems, and also occasionally twigs, is lined with grasses and a thin-walled mud cup. The innermost lining, within the mud cup, is of very fine dry grass blades.

On their Continental breeding grounds, fieldfares tend to be loosely colonial, but there are hardly enough of them in Britain for this to be apparent.

Right: A fieldfare finds a heap of apples specially provided for birds in winter. When mid-winter arrives, the elderberries, rose hips and hawthorn berries have become scarce, and most soil animals such as worms have burrowed out of reach of the short beaks of fieldfares and redwings. Also, the snow covers the leaf litter in woodland, and puts this important source of food out of the birds' reach. Thus they are forced to scavenge on rotten fruit in orchards; at this time of year it is particularly helpful to put out fruit for birds that may be in serious difficulty.

MAMMAL PREDATORS: THE HUNTING LIFE

Mammalian predators, both terrestrial and aquatic, are intelligent, adaptable and efficient. Each species has a different life-style, but all the members of the order Carnivora have teeth that are adapted to cutting and shearing a variety of prey.

Above: The otter preys on slow-moving victims, especially eels and coarse fishes, but also crustaceans, waterfowl and such small animals as shrews, water voles, toads and frogs. The otter belongs to the order Carnivora, which includes the fox, pine marten, weasel, polecat, mink, stoat, wild cat, dogs and domestic cats. Other British predatory mammals are the grey and common seals, and some whale species.

The mammals appeared about 200 million years ago when dinosaurs were only just beginning to be widespread and successful. For the first two-thirds of their long evolutionary history the mammals remained a relatively unimportant group of small, nocturnal animals. They fed mainly on insects and other small creatures, but when larger forms evolved, a few of their descendants adopted predatory, flesh-eating habits.

Most of today's predators belong to the single order, the Carnivora, which includes the superfamilies of the dogs and cats. The seals and sea-lions belong to a related order, the Pinnipedia. Then there are the carnivorous toothed whales in the order Cetacea, while in Australasia and South America some of the marsupials have also produced carnivorous types.

Britain's carnivores Since wolves were exterminated in the British Isles in the 18th century the largest British land carnivore has been the badger. Although it is endowed with astonishing strength of jaw, the badger is not really a predator. It is almost omnivorous, feeding on roots, nuts, fungi, slugs, snails, frogs, voles, mice, rats, birds' eggs and insects, including the larvae of wasps and bumble bees. The largest British carnivore predators are otters, foxes and wildcats but, like all carnivores, they also supplement their diet with insects, fruits and other foods.

Well-adapted bodies The bodies of mammal predators are adapted in various ways to make them efficient hunters. The wild cat, for instance, has several specialisations for hunting. Its shortened skull is large to hold the well-developed brain, necessary because in stalking prey which is out of sight or, perhaps, cannot even be smelt, the cat may have to learn to associate the presence of food with obscure clues such as footmarks, or to lie in wait for prey that is still far away. Cats even learn to catch small birds by hiding motionless in long grass until the prey comes close enough to be captured with a quick dash. This kind of behaviour requires a large brain and considerable intelligence. The skull also contains powerful muscles so that the cat can

Above: Polecats frequently kill rabbits and they also take game birds and poultry. They shake their victims—a learned rather than an instinctive characteristic; young polecats do not always make a clean kill.

Left: The fox is mainly a solitary hunter, although it hunts for its family during the breeding season. It takes animals smaller than itself, biting them in the shoulder or neck and shaking them violently.

Below: The most common killing technique of the cat is a bite in the nape of the neck of its prey, driving the canine teeth into the spinal cord.

open its mouth wide, then snap the jaws together, stabbing the prey with its long, sharp teeth. Different muscles control the shearing motion.

The cat's feet are also adapted for hunting. There are five digits in its front paw and four in its hind foot. They are armed with sharp, retractable claws which are important weapons of offence and defence, while the body weight is carried on special pads. The cat walks on the 'palm' of its front paws and on the soles of its back feet—an unspecialised gait known as 'plantigrade'. In members of the dog family, which are adapted for chasing prey over long distances, the gait is 'digitigrade': like human athletes, dogs run on their toes.

Many predators have rather long bodies and carry much of their weight on their forelimbs. The bodies of weasels, stoats, pine martens and polecats, especially, are long in relation to their total length; weasels, for instance, can easily run down tunnels after prey.

The teeth of carnivores are differentiated into small incisors, large canines used for killing prey, premolars and a somewhat reduced number of molars. The last upper premolars and the first lower molars on each side of the jaw are enlarged as the 'carnassial' teeth. In their most highly developed form, as in cats, these are sharp, flattened blades that sweep past each other with a scissor-like action, cutting meat and bone into fragments. Carnivores do not chew their food.

Many British carnivores are nocturnal. Their eyes have a glistening layer or 'tapetum' behind the eyeball which, at night, reflects light back through the retina, giving each ray a double chance to stimulate one of the sensory rods. The effect can be seen after dark when the light from a torch or the headlamps of a car is reflected back from the eyes of a dog or cat. The pupils expand in the dark and contract in the sunlight.

Different hunting techniques Most carnivores, apart from the stoat, kill prey that is smaller than themselves. There is, in fact, a fundamental difference between the ways of hunting of the family Mustelidae (weasels, stoats, martens etc), the Canidae (dogs and foxes) and the Felidae (cats). Many carnivorous animals are solitary, but some species hunt in packs. Weasels and stoats, for instance, may be found hunting singly or in family groups.

Weasels hunt mainly among dense vegetation and are small enough to follow voles, mice and rats down into their underground tunnels. They also eat young rabbits. Pine martens prey on voles, mice, squirrels and birds. Stoats are exceptional in that they hunt hares and rabbits, which are much larger than themselves, as well as mice, voles, shrews and small birds. They will sometimes prance about to attract an inquisitive bird, then pounce on it and bite its neck.

In general, dogs hunt their prey by tracking

and chasing, assisted by their excellent sense of smell, long legs, deep narrow chests and tremendous endurance which enables them to travel long distances before they attack their prey and tear it to pieces. Although cats, too, have long bodies and powerful muscles which react extremely quickly, they soon tire. They capture their prey by stealth, first stalking it, then pouncing. They direct their attacks at the head, whereas the Canidae usually attack from the rear. Unlike dogs, cats are equipped with sharp claws and powerful forelimbs to overcome the defensive weapons of their victims.

A cat stalks its prey using a series of distinctive movements. At first it crouches, slinking towards the victim with its body close to the ground. Then it pauses, in ambush, moving slowly and silently forward behind cover until close enough to launch a lethal attack. Wild cats often tear the heads off larger prey such as rabbits to eat the brains. Smaller prey is frequently stored before being eaten, the wildcat visiting its cache from time to time.

Marine predators Seals are marine carnivores, distantly related to the terrestrial Carnivora. They swim fast by flexing the whole body, using their hind flippers to propel themselves. Their teeth are rows of oval cones, although the canines are large. Their eyes are directed upwards, and the fish or squid prey is often caught from below and swallowed whole. The external ears are greatly reduced, but the hearing is acute. The numerous long hairs (vibrissae) on the muzzle are very sensitive, enabling them to fish in deep water and at night.

Many of the smaller toothed whales, such as the porpoises and dolphins, prey mainly on fishes. Their elongated jaws contain numerous peg-like teeth in long rows. These have lost their function of chewing and serve only to hold their slippery prey. The dolphin, for example, has 40-50 slender, peg-like teeth with which it captures agile fishes or squid. Porpoises have teeth with lobed crowns so that they can take bites out of their prey. The killer whale uses its large powerful jaws and stout teeth to feed on dolphins, birds, seals, and even the flesh of large whales.

Prey escape Although prey animals are often faster than their enemies, they are generally less intelligent and adaptable. Consequently the sick and weak often become the victims of predators. Undoubtedly natural selection sets its mark most distinctively on the form and behaviour of animals in response both to the capture of food and escape from predators.

Most prey species seem to take refuge in flight on the approach of a predator. The effectiveness of this is often enhanced by jinking and zigzagging, which can be seen in creatures as different as field-mice, voles and hares as well as ptarmigan, gulls and sandpipers.

Predators and prey

Predator attack strategy **Prey defence strategy**

Fox hunts using all its senses, strong legs; bites and tears food.

Hare pricks ears at danger, can run at high speed away from predator.

Wildcat stalks prey crouching; pauses, attacks, drives teeth into spinal cord.

Hedgehog in open grass curls into tight ball protected by prickles.

Weasel hunts after rodents in their underground tunnels, kills with bite.

Woodmouse is nocturnal, secretive, camouflaged in dark leaf mould.

Otter kills prey with fierce bite, then uses front paws to handle it.

Rabbits show their white tail patches to warn others of danger.

Grey seal swims fast after slippery prey, catches it using sharp teeth.

Fallow deer females show alarm by 'flashing' white rump patches.

WATERSIDE PLANT COMMUNITIES

On the banks of slowly moving rivers and canals, by the sides of ponds and lakes, and in the ditches separating low-lying meadows is an ever-changing community of waterside plants, including such attractive species as yellow flag and purple loosestrife.

Below: Two of our most beautiful waterside plants: purple loosestrife (*Lythrum salicaria*) and meadowsweet (*Filipendula ulmaria*). Purple loosestrife is an upright perennial growing to a height of 1.2m (4ft) and producing spike-like inflorescences of vivid purple flowers in the summer. Meadowsweet—also a perennial species—grows to the same height and flowers at the same time of year as purple loosestrife. Its creamy-white flowers are borne on umbel-like heads.

Any pond or ditch, if it is not fed by a supply stream, is gradually invaded by larger and larger plants until it becomes silted up and boggy. The same would be true of water margins if they were left alone, but they rarely are. Most canals, rivers and ponds are maintained regularly, either by the local council or by the local water authority. The vegetation is cut and the silt removed. If this maintenance is done properly and not too frequently then a rich and balanced flora is achieved.

Pioneer plants The first species to colonize recently cleared shallow water is the common reed. The reeds grow by means of creeping underground rhizomes, from which arise erect hollow stems up to 3m (10ft) tall. The stems support long graceful inflorescences up to 20cm (8in) in length. With time an extensive reed swamp may build up, providing a home for a multitude of water birds, amphibians, insects and other creatures.

The reeds often share a water margin with bulrushes, especially where the silt contains a high percentage of decaying vegetation. Unless cut back, these plants grow too tall to allow much competition from smaller species. Their aerial parts die back each winter, falling into the water where they decompose and form a layer of peat. The water becomes increasingly shallow and the reed swamp is transformed into fen. However, if the reeds are cut regularly for thatch, or if the plants are growing along the banks of a canal or ditch where they are often cut and cleared away, then other species have a chance to establish themselves.

Reed swamp species Reed swamps often contain large colonies of purple loosestrife. This clump-forming perennial has large, somewhat lance-shaped, entire leaves borne on stout stems which may grow to a height of 1m (3ft). Small purple flowers grow in the axils of the upper leaves.

A quite different species associated with reed swamps is the sweet flag. This plant is not native to the British Isles. It was introduced here during the Middle Ages, when it was used to strew the floors of halls and churches: if bruised its leaves give off a sweet scent reminiscent of oranges. It is an easy plant to recognise because its leaves have characteristically crinkled margins. The flower heads consist of a cigar-shaped spike (called a spadix) bearing clusters of tiny greenish-yellow flowers, males on the upper part of the spadix and females on the lower part. The flower heads bear some resemblance to those of cuckoo pint, which belongs to the same family, the arum family.

Outside a reed swamp Even when the reeds are cut back periodically, a reed swamp nevertheless contains only a fairly narrow range of plant species. Most of our prettiest waterside flowers are found outside reed swamps, often as part of a very mixed community of plants.

The yellow flag, which is a species of iris, is a spectacular member of such communities. It grows in ditches and water margins all over the British Isles, and its large clumps of linear (grass-shaped) leaves can transform a waterside bank in early summer.

Other aquatic irises found in Britain include the blue iris, a blue-flowered species which grows in the ditches of Lincolnshire, and the purple flag, an introduced species from North America with pale purplish flowers. It has grown on the banks of Ullswater and other lakes of northern Britain for more than 40 years.

Another familiar plant of river banks, ditches and pondsides is meadowsweet. This large clump-forming perennial has stout

Left: Indian balsam (*Impatiens glandulifera*), naturalised beside a duckweed-covered pond. Introduced to Britain from its native Himalayas, this species has now escaped from gardens and established itself by waterways. Balsams are also known as touch-me-nots, a reference to the explosive nature of their fruits (seen here as pinkish-green hanging capsules). When ripe the fruits rupture violently at a touch, spitting out their seeds, which are then dispersed by water. The Indian balsam grows to a height of 2m (6ft), despite being an annual, and flowers from July to October.

Right: The monkey flower (*Mimulus guttatus*) is another introduced species that has successfully established itself in the wild here. Its common name comes from its flowers which, when seen from the front, can resemble a comical monkey's face. Seen close to, the flowers have red spots in their centres, which is a useful identifying feature, though they are not visible in this picture. This species flowers throughout summer.

stems, growing up to 1.2m (4ft) high and clothed in dark green leaves. In mid-summer the tops of the stems become covered with a froth-like mass of creamy-white, sweet-scented flowers.

Smaller species The plants described so far–meadowsweet, irises, reeds and bulrushes–are all tall, but a great variety of smaller plants can also be found along a water margin. Whenever a gap develops along the edge of a pond or in a ditch you are likely to find a riot of small plants competing for space.

Several species of mints grow by the waterside, for instance the water mint, a species that looks rather similar to our own garden mint though it has a different scent, more akin to that of peppermint. Pennyroyal is another species of mint sometimes found along the waterside. It, too, smells strongly of peppermint. Neither species grows to a height much more than 50cm (20in).

One of the glories of the river bank is the monkey flower. This is an introduced species, native to the western part of North America. It is now extensively naturalised in Britain, largely because it spread along canals during the 19th century. A creeping perennial, its stems are rather brittle and much branched. In spring they send up flowering shoots and, by early summer, the whole plant is covered with distinctive red-spotted yellow flowers.

City colonizer Sadly, not all river and canal banks are attractive. In industrialised areas with polluted waters the waterways and their banks are often dead or dying. However, in recent years, these ugly sterile areas have become colonized by a plant from the Himalayas. This is the Indian balsam or policeman's helmet, a garden plant that has escaped into the wild and seems to thrive beside these inhospitable city waterways.

Several other balsam species grow along our riversides. Touch-me-not balsam is probably native to Britain and grows beside streams in the Lake District and Wales. It has bright yellow flowers. Orange balsam (named after the colour of its flowers) is an introduced species found along the Thames and its tributaries.

Below: The largest and most spectacular of Britain's aquatic irises is the yellow flag (*Iris pseudacorus*). This species, which grows to a height of 1.5m (5ft), spreads by means of thick rhizomes and can form large colonies.

Above: Soon after emerging from her pupa, the female cuckoo bee *Psithyrus bohemicus* collects pollen in order to build up her food reserves for winter.

CUCKOO BEES: NEST PARASITES

Not all bees are capable of building their own nests. Some – cuckoo bees – parasitise bumble bee nests, but not without a fierce fight.

Not all the bumble bees you see on flowers are true nest-making bees. A proportion of them are social parasites, similar in many ways to the cuckoos of the bird world. For this reason they are known as cuckoo bees and, since they are adapted to a fully parasitic life, they belong to a separate genus, *Psithyrus*, from the true bumble bees (*Bombus*) which they victimize.

Through the course of evolution cuckoo bees have become incapable of setting up and looking after their own colonies, partly because they do not have any workers to feed their larvae – all their eggs develop into females or drones (males) – and partly because they cannot secrete their own wax with which to build egg cells. Consequently, if they are to reproduce successfully, they must invade the nests of bumble bees.

Feeding on flowers The young female cuckoo bees, in common with queen bumble bees, mate in summer, soon after they have emerged from their pupae, and then visit flowers to build up adequate food reserves for winter. They then seek out or make burrows in which to pass the rest of the summer and all the winter.

The following spring they come out of hibernation – a few weeks after the bumble bees – and spend most of their time on flowers, feeding on pollen and nectar to mature their ovaries. If you see a large bumble bee-like species covered in pollen it is probably a female cuckoo bee as, unlike the bumble bees, it does not have specialised leg combs for removing the pollen or pollen baskets on its hind legs.

Forcing an entry As soon as her ovaries begin to develop, the female cuckoo bee looks for a suitable nest to take over. Her flight has been described as 'laboured', with a deeper buzzing tone than the bumble bee, so you should be able to distinguish her.

When the female cuckoo bee has found the entrance to a suitable colony, she tries firmly, but slowly, to enter. Not surprisingly, her arrival is challenged by the worker bumble bees, which have been known to drive her off or even kill her. Normally she tries to avoid them, or feigns death by hiding beneath the

Parasite and host

Above: *Psithyrus bohemicus* (top) closely resembles its host – the bumble bee *Bombus lucorum* (bottom).

comb or elsewhere in the nest. This enables her to take on the colony's scent – an essential requirement if she is to take over the nest.

The choice of nest is important, for in a colony which has too many workers, the cuckoo bee may meet with too much resistance. The most favourable nests, from the point of view of the cuckoo bee, are those with only the first brood of workers – they tend to be small and less aggressive.

If there are not enough workers, the female cuckoo bee may be confronted by the foundress queen at her most aggressive, and a fierce battle can develop in which the bumble bee queen is usually killed. This is of no great help to the cuckoo bee, however, since the colony is too weak to support her own young. Normally the cuckoo bee female chooses her time of attack accurately – when there is a sufficient number of workers – and manages to introduce herself into a suitable colony quite easily.

Parasitic young Once settled into a colony, the female cuckoo bee sets about destroying all the bumble bee eggs and young larvae (older broods are left alone as they produce more workers). If the existing workers try to prevent her destroying the eggs, she attacks them with her jaws, but does not actually sting them.

The cuckoo bee collects wax from the bumble bee combs to build her own egg cells and then lays as many as 20-30 eggs in a single cell within the space of a few minutes. Some of the older workers may try to break down the cell, but the cuckoo bee proves herself more than able to defend it.

The young cuckoo bee larvae are tended by the workers, and the colony, for a time, looks quite normal, with more brood clumps appearing as the female makes more cells and lays eggs in them. However, as no fresh worker-producing eggs are laid the colony dies out earlier in the season than a normal bumble bee colony.

The cuckoo bee males leave the nest soon after they have emerged from their silken pupal cells, and spend the rest of the summer on flowers and looking for mates. They do not hibernate, and after mating die in the autumn.

Cuckoo bee species There are six species of cuckoo bee in Britain, each one having its own preferred host species of bumble bee. In southern England the most common species is the vestal cuckoo bee (*Psithyrus vestalis*), a large species with the female reaching 20-22mm ($\frac{3}{4}$in) long. It has a yellow band on the front of the thorax and a white tail, edged along the front with yellow hairs, making it very similar to its host, the large earth bumble bee.

In the north of England, *Psithyrus vestalis* is replaced, to some extent, by *Psithyrus bohemicus* which attacks the small earth bumble bee. Another well-known, though less common, large species is the hill cuckoo bee (*Psithyrus rupestris*) – a black bee with a red tail. The female, which has brown wings, victimizes the red-tailed bumble bee.

Above: The vestal cuckoo bee (*Psithyrus vestalis*) is the commonest species in southern England, and is recognised by the yellow band on the front of its thorax, and its white tail.

Right: This black species is the hill cuckoo bee (*Psithyrus rupestris*), a parasite of the red-tailed bumble bee.

Below: It is quite possible that the pollen collected by this worker will feed a parasitic cuckoo bee queen.

At any time of the year an estuary is a rewarding place for the naturalist, particularly the birdwatcher for whom it provides an unparalleled chance to study waders and wildfowl.

Estuaries are sheltered shallow inlets, often as complex in shape as a river delta, where sea meets river at the turn of the tide. Being shallow, estuaries tend to be much warmer than the open sea and therefore much richer in food. Furthermore, this richness is enhanced by various minerals and nutrients carried down along with the silt as the river flows into the sea. Thus the estuary, no matter whether it is sandy or muddy, contains copious plant life, especially such algae as the floppy, green sea-lettuce, while the ooze literally teems with life.

Planning your visit Estuary visits demand rather different planning from most other natural history excursions. For a start, clock times have little impact on the tempo of estuary life. Here the pattern is set by the changing tides and, as high water falls between 30 minutes and an hour or so later at each tide (there being two tides each day), a tide table is essential. Most local papers carry one, and even reference to a national daily paper for high water times at London Bridge

Above: At first sight seemingly almost barren of life, estuaries can reveal a great diversity of plants and animals, both on and in the ooze, if you know how to observe them.

Below: A tripod is essential for supporting a telescope if you want a steady view. Buy one that has both spiked and rubber feet, and make sure when you set it up that it is secure against the ground before you attach the telescope in case it topples over.

Choosing a telescope

There are many different models on the market; before you decide which to buy, here are some points to bear in mind:
1 Variable magnification (zoom) telescopes are easier to use than fixed ones – they allow you to pick up your subject at low magnification and then 'zoom' in on it.
2 On some models you lean your eyebrow on the eyepiece, on others the eye must be held back a short way. The former are much more comfortable.
3 Some models are to be looked straight through while others have their eyepiece at 45°. The latter are more comfortable to use but take some getting used to.

will allow you to calculate the times of high tides.

However, it is not quite as simple as this. For a start, when is the best time of year to visit? Experience must be your guide. For entomologists and botanists the season is immaterial, the species being constant all the year round, although the warmer months will inevitably be more rewarding. But birdwatchers and those wishing to investigate the small mudflat animals must experiment, not only with the times of year but also with the times of day.

Some birdwatchers prefer a rising tide, which pushes ducks and waders towards them over the mudflats. Others like to arrive when the tide is at its full, and wait and watch as birds fly in to the freshly exposed mud to feed. At high tide, the ducks will be out in midstream and not easy to see, but waders usually congregate in a few roosts, often thousands or tens of thousands of birds strong.

But time of tide is not everything. There is little point in visiting an estuary on a fine late afternoon if your view is always to the west and all you see are silhouettes. Similarly, in midwinter it becomes almost impossible to continue watching for any length of time into the teeth of a north-easterly gale, no matter what interesting birds (such as skuas) it may have blown inshore. So, as ever, a map is an important starting point.

What you will need Before you start out, make sure you are properly equipped for the conditions. As well as a map and a tide table you will need to take weather-proof clothing, no matter what the time of year.

Birdwatchers will find that on estuaries the extra power of x10 binoculars are well worth the weight of carrying them. For the dedicated watcher, or those wishing to see at really close quarters the different feeding techniques of estuary birds, a modern variable magnification telescope is also well worth carrying. But you will need to take along a tripod as well if you want a steady view. The requirements are different for those interested in the small invertebrates that abound in estuary ooze. You will need a small lightweight bucket, a trowel, a fine sieve (the sort used for sieving flour, about 12cm/5in in diameter, is excellent) and a shallow white dish (plastic photographic developing trays are ideal). A x10 hand lens is also essential.

Setting out Before you start out, a word of warning: estuaries are dangerous places. *Never venture alone on to the mudflats*, no matter how solid they appear. If you wander on to the saltings – those islands laced with small creeks called runnels – always remember how quickly the tide can come in, filling the runnels behind you and giving you a damp and chilly few hours until it recedes.

You may set out in a thin early morning fog, with the sun visible only as an aura; birdwatching then must, for the moment, be by ear rather than by eye. With luck the mist will clear later, and indeed it may be some benefit in that you can reach the first good vantage point unseen by the birds. With nothing to frighten off, you can reach the estuary along the sea wall (a feature present on many British estuaries). If birds are about, it is not difficult to drop down out of sight and use the wall as a natural hide.

Above: Take along a bucket and sieve to examine life in the estuary ooze. Here the author is washing away the sand and silt from the sieve before inspecting his catch – a x10 hand lens is very useful for this. Notice the importance of putting on wellington boots before you do this.

Plant life Sea walls have their fascination for botanists and entomologists during the summer months, although they are not at their best in winter. This is a harsh environment, with relatively few tough specialists; particularly predominant plants are the plantains, thistles and sea beet. Most flowering plants (and most of the insects too) will be near the top of the sea wall and in sheltered crevices. Be prepared for surprises, though. In 1953 much of south-eastern England's marshland was inundated by a surge tide in the North Sea. The subsequent raising of the sea wall used soil often taken from far inland, and the occasional downland plant, crimson vetchling (grass-leaved pea) for instance, still flourishes on the sea wall after its enforced

Below: A redshank searching for food at low tide. On an estuary, you are unlikely to get very much closer to a bird than this, so a telescope, or at least a pair of powerful binoculars, is a must.

Above: In the summer, some colour is provided on the saltings by plants such as sea lavender (shown here), with its sprays of pinkish-mauve flowers appearing from July to August. Other colourful species you might see include sea aster, which resembles a tiny Michaelmas daisy, and golden samphire. For most of the year, however, the saltings appear grey from the presence of grasses and sea purslane (see opposite page). On the left of this picture is sea samphire.

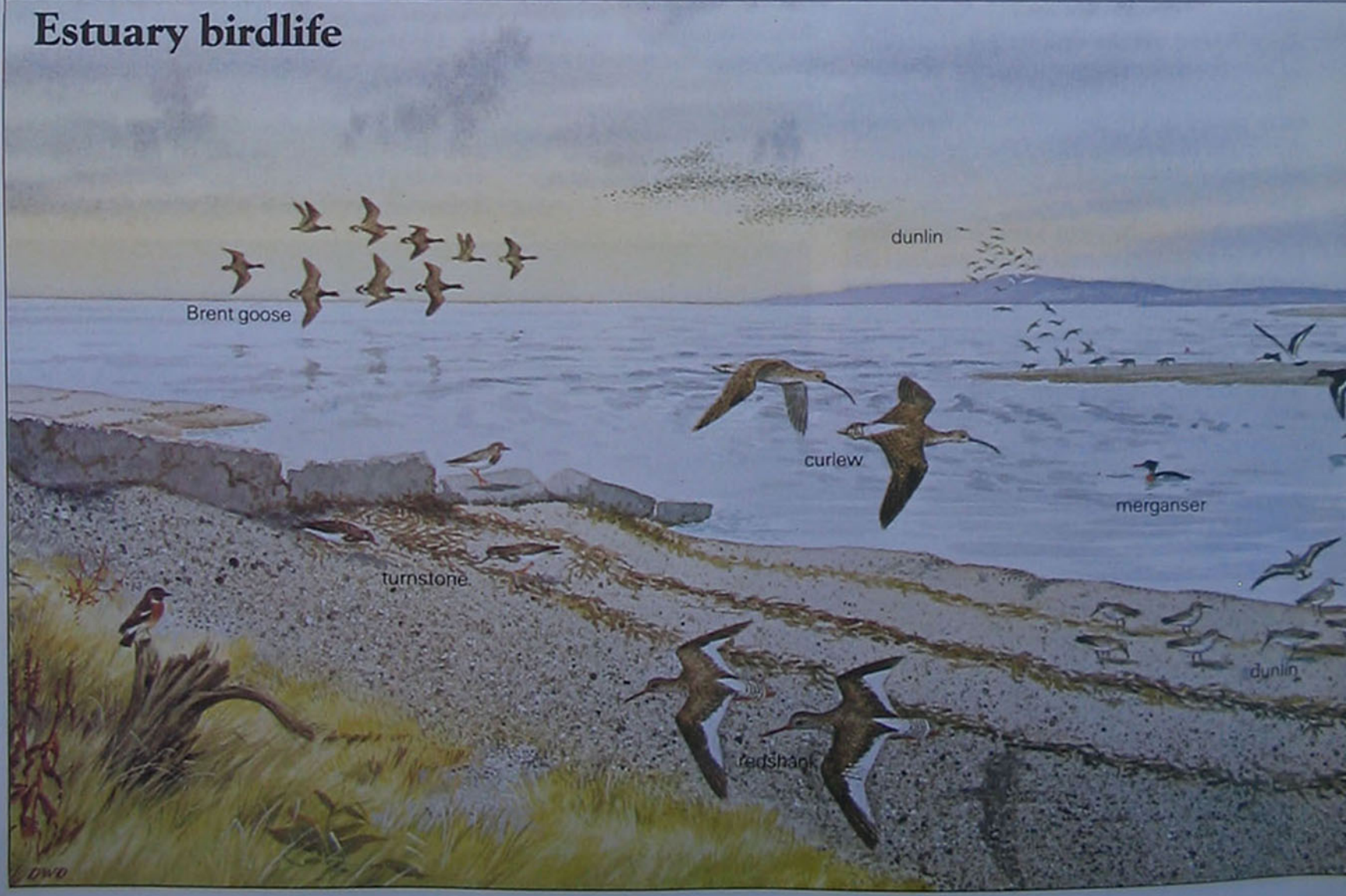
introduction.

The mudflats and saltings have much the same appearance year round. The vegetation has to be able to tolerate a wide range of salinity, plus regular exposure and inundation as the tides come and go. On the mudflats the sea lettuce and that odd plant, the eel-grass, both beloved by wigeon and Brent geese, spread a green sheen. The sea lettuce and the conspicuous clumps of *Spartina*, or rice-grass, harbour millions of tiny snails, and these the shelduck relish noisily, slurping them up like spaghetti-eaters. *Spartina* clumps tend to collect silt between the stems, and over the years the soil level may rise sufficiently to give adequate footing for other plants, such as the fleshy-leaved glasswort, ultimately producing a new island to replace those lost to wave erosion elsewhere.

Life in the ooze Each square metre of mudflats contains millions of worms, shellfishes and other invertebrates, and this is where you may begin your investigation of the animal life, for although estuaries are the Mecca of birdwatchers, there is plenty to interest the less specialised naturalist. Birds are, of course, attracted to estuaries because of the rich food potential, extracting the creatures from the mud with ease. We, however, must use other techniques to see them. Collect some water in a bucket, then place a trowelful of mud in your sieve and wash it through. Sand and silt will wash away, leaving the various organisms on the sieve. Often invisible at first sight, look for movements among the particles which give away the presence of tiny creatures. To examine your finds closely, place them in your white dish. Watch the bivalve shellfishes in case they extend a fleshy foot in an attempt to pull themselves away to safety: put them back on the mudflats and see how quickly they can pull themselves beneath the surface.

Birdwatching Any time between autumn, through winter, to the following spring can be a rewarding time for the estuarine birdwatcher. It should be remembered, however, that a bird sighted on one visit may be totally absent the next. Like any other habitat,

Estuary birdlife



estuaries are subject to the feeding whims of their inhabitants. Also, some of the species described here may always be absent from a particular estuary, but others–perhaps rare species–may be quite abundant.

The distances and open nature of estuaries demand powerful binoculars, or a telescope, and a 'sit and wait' technique rather than that adopted while looking at woodland birds, for instance.

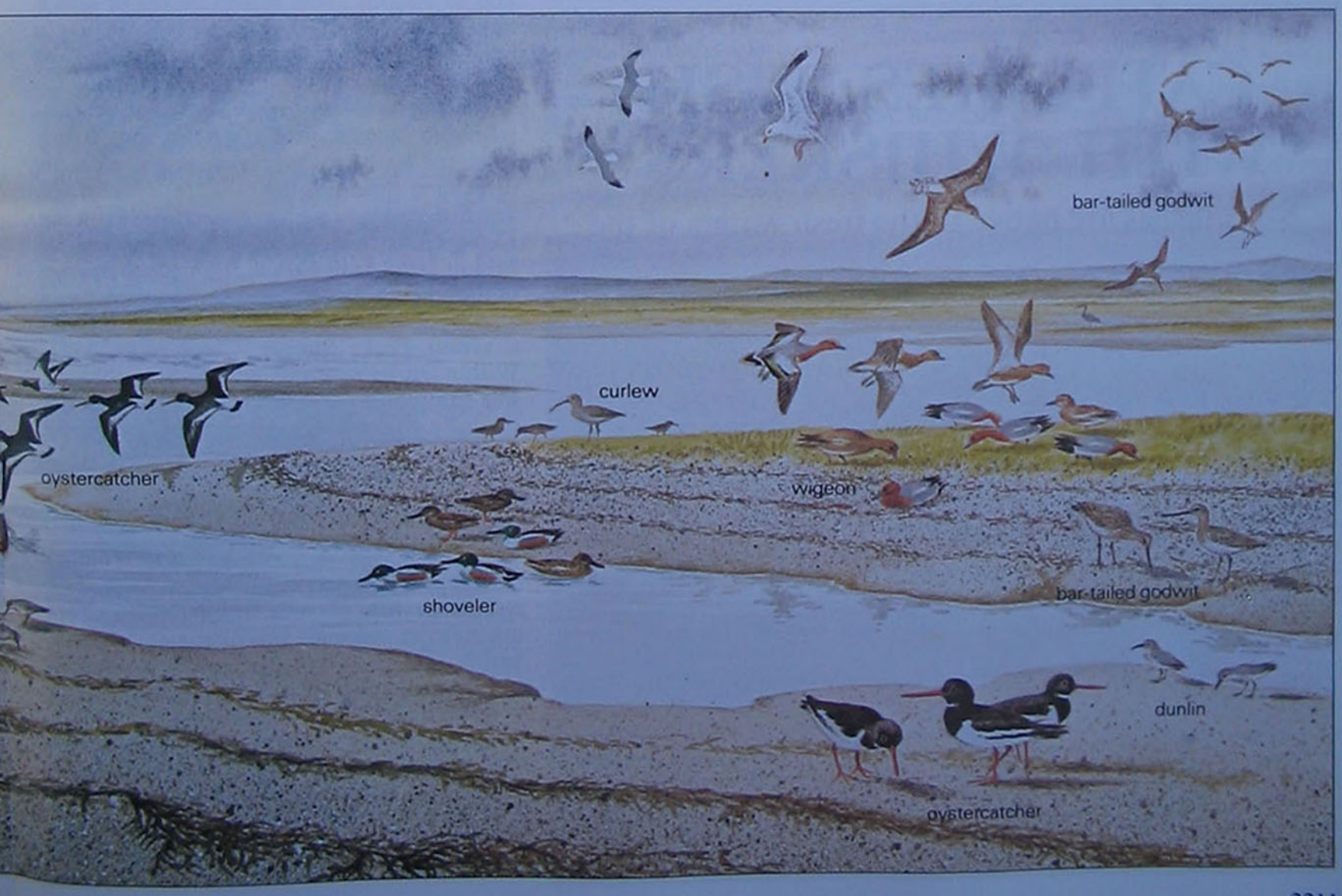
Your first objective should be a sheltered niche in the sea wall offering shelter and a good view, reaching it with the tide about halfway in. Here you can watch ducks, waders and gulls at your leisure, but the telescope is essential. Keep a cautious eye on the time, because other objectives, such as a deep-water channel or a nearby roost, are best watched at high water, so fine judgement is needed to get the best views of the ever-nearing waders and waterfowl and still leave time to reach the next viewing place.

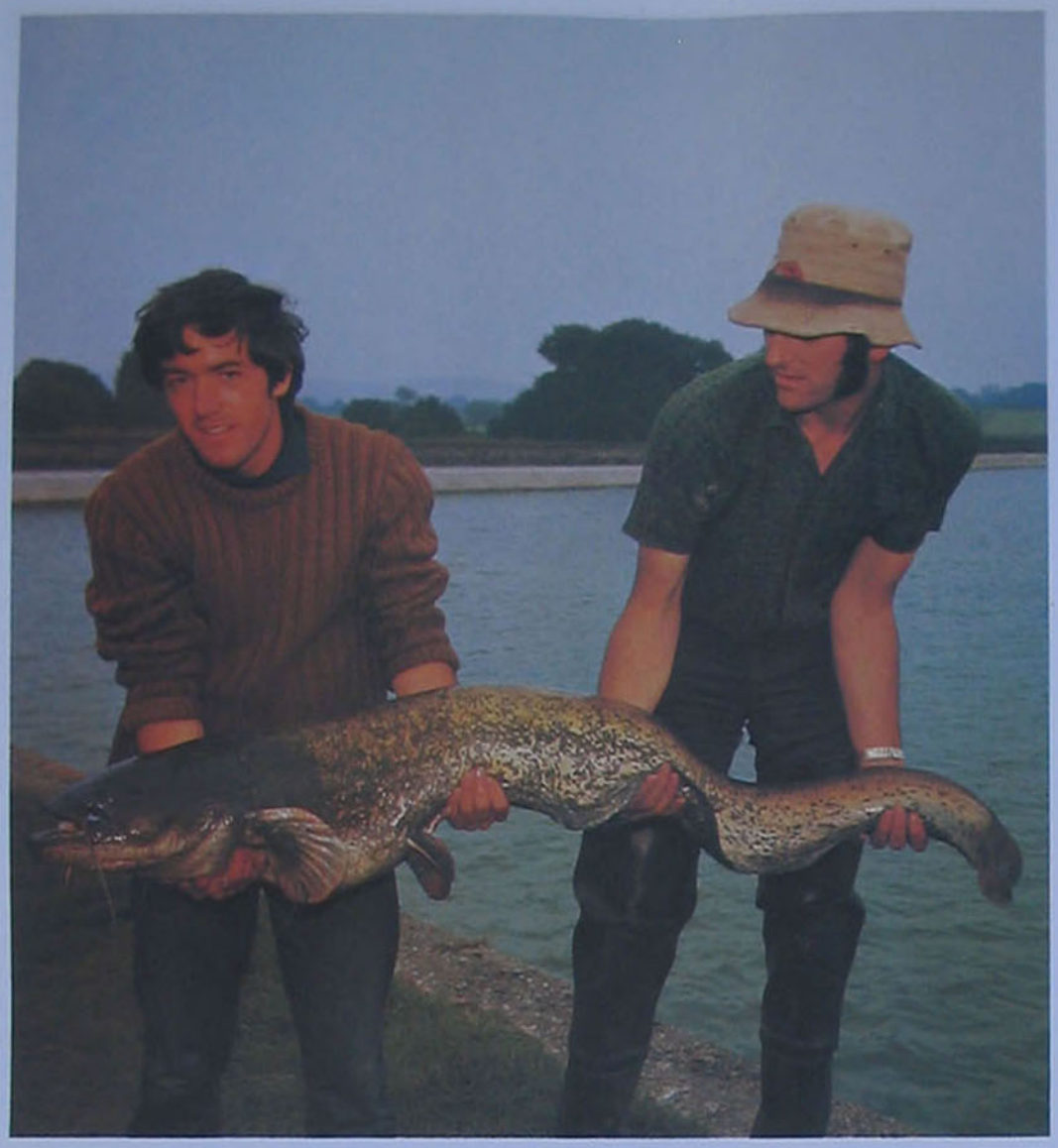
Several hundred yards from the target, drop down behind the sea wall, crawling up on hands and knees when you get there. A bit of wriggling and flattening of offending blades of grass allows a clear view of the deep water where the channel cuts close to the sea wall. With luck you can get a good view of golden-eye, grebes and divers, and perhaps merganser or goosander as a bonus, all diving birds preferring deeper water to the shallows. Apart from a few latecomers, received with ill-

concealed annoyance and much shuffling by those birds already on one leg, beaks tucked into their scapular feathers and eyes closed, high-tide wader roosts will be complete. Over the next hour, little happens, but then small groups of birds begin to depart, often turnstones first, as their rocky man-made feeding zones at the base of the sea wall are the first to be exposed.

You can return from your vantage point at a leisurely pace, perhaps dropping down behind the wall to get close to any interesting species you may have come across. Often the Brent geese and other birds will gather round a drainage outlet, where fresh water for them to drink runs off the marshes.

Below: Estuary birds are usually too far away for easy identification, so watch and listen for these tell-tale signs.
Brent goose Smallest of the geese–no bigger than a mallard.
Turnstone Black and white chequered bird often seen near sea walls.
Redshank Distinctive white wing bars; noisy, strident, whistle-like call.
Curlew White rump visible in flight; large wader with a down-curved beak.
Dunlin Small wader, arrives mysteriously in twisting, shimmering flocks looking like smoke in the distance.
Merganser Short-necked bird; rides low in water.
Oystercatcher Gathers in exclusive black and white huddle. Distinctive red legs and beak. Flies in fast skeins over the water.
Shoveler Typical mud-feeding duck. Colourful.
Wigeon Distinctive white wing patch and piercing whistle.
Bar-tailed godwit Arrives by tumbling out of the sky in an erratic spiral.





CATFISHES: FISH WITH 'WHISKERS'

No catfishes are native to the fresh waters of the British Isles but, from time to time, several different species have been introduced from Europe and North America, and at least one – the wels – is now well-established in various English waters.

Above: This wels being so proudly displayed holds the present British rod-caught record. Caught in Wilstone Reservoir on 26 September 1970, it was 1.5m (5ft) in length and weighed an amazing 19.7kg (43½lb). Note the long anal fin of the fish.
The first successful introduction of the wels to British waters occurred in 1880, previous attempts in 1864 and 1872 having failed. Other names for the wels include the Danube catfish and the sheat-fish.

The Siluridae is a major family of catfishes in the Old World and its species are found in Europe and Asia. There are eight genera in the family but only one of these, *Silurus*, occurs in Europe. The commonest species of *Silurus*, the wels, is found in the lower reaches of large rivers and rich, muddy lakes in most of central and eastern Europe. It also occurs in brackish water in the Baltic and Black Seas. (Many species of catfishes have been imported for aquarium purposes from Africa, Asia and South America, but these could never acclimatise in the wild except, perhaps, in the vicinity of heated effluents from power stations and factories.)

The weighty wels Like the other members of the family, the wels is a scaleless fish with a flat head, an elongated body and a large anal fin terminating near the tail fin. It has a wide mouth with two barbels on the upper jaw and four on the lower jaw. These whiskery appendages have a sensory function, assisting in the finding of prey. The wels can grow to an enormous size and is one of the largest freshwater fishes in the world.

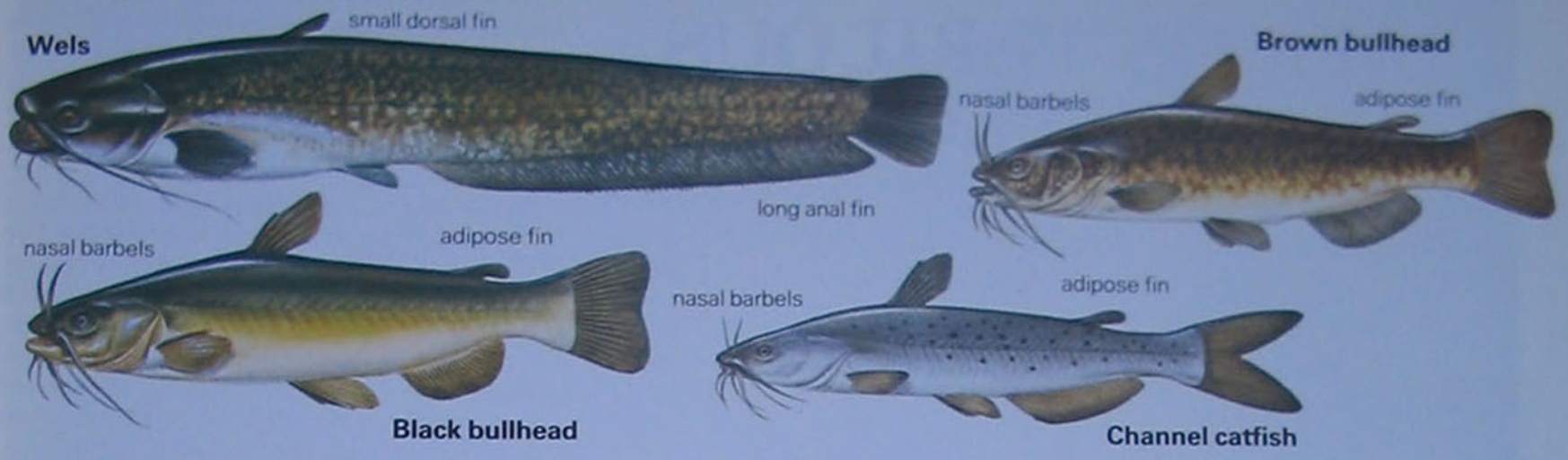
The earliest attempt to introduce the wels into the British Isles seems to have been made in 1864, when 36 specimens were brought by Sir Stephen Lakeman from a tributary of the Danube near Bucharest. Fourteen specimens survived the journey and ten of them were released in a pond at Aldermaston Park, Reading. At about this time, too, Sir Joshua Rowley released other specimens into a lake near Flatford Mill, Suffolk, while some years later (in 1872) the Marquess of Bath introduced some to his lake at Frome in Somerset. None of these introductions appears to have been successful.

The largest, and first successful, introduction of the wels to Britain occurred in 1880 when 70 fishes were put into the lakes of the estate at Woburn by the Duke of Bedford. These fishes thrived and bred successfully. When the lakes were netted in 1947 and 1951 many specimens were caught and one over 1.5m (5ft) long was reported. Stock from Woburn was introduced successfully to Marsworth Reservoir, to a lake in Claydon Park and to various other waters (some of which have now been filled in). The wels is now a firmly established species in this part of southern England.

Angling incidents Anglers have shown considerable interest in the wels in the British Isles and have, indeed, been responsible for dispersing it within the country. One of the first fish caught was a large specimen weighing 13.6kg (30lb) from the River Stour at Flatford Mill in 1894. Fish netted originally from one of the lakes at Woburn were taken away by an angling club and released in the middle lake at Claydon Park, Steeple Claydon in 1951. Within ten years of this introduction the wels was quite common in this water, breeding successfully. Specimens were regularly caught by anglers.

Indeed, on 18 June 1961 one of the largest wels recorded in Britain was caught here by an angler from Leighton Buzzard – someone who specialised in catching wels. Having caught one of 4.6kg (9½lb), he then hooked an enormous fish of over 15kg (33½lb). This magnificent specimen was over 1.4m (4½ft) in length. This same angler then went on to catch another fish of over 8kg (17lb). In 1969 at least 35 specimens were caught, all of them weighing 3-11kg (7-25lb). The largest wels ever caught in Britain appears to have been angled on 26 September 1970 in Wilstone Reservoir. It weighed over 19.7kg (43½lb) and was 1.5m (5ft) in length. This fish is the present British rod-caught record.

Catfishes introduced to Britain



Above: The wels (*Silurus glanis*) and the black bullhead (*Ictalurus melas*) have both established successful breeding populations in British waters. The brown bullhead (*Ictalurus nebulosus*) and the channel catfish (*Ictalurus punctatus*) have both been introduced here several times, but so far without success.

If conditions are favourable, the wels can grow to a very large size, reaching at least 1-2m (3-6½ft) in length. A 5m (16ft) specimen has been recorded from Europe. This enormous fish weighed 306kg (673lb).

Breeding and feeding The wels spawns in June and July in shallow water among thick vegetation, where the male fish excavates a depression in which the eggs are laid. Each female produces about 1000-5000 eggs, which are guarded by the male until they hatch some two to three days after being laid.

The young fishes mature after four or five years and may live for about 15 years. Small fishes feed on invertebrates (crustaceans and insects) at first, but soon grow and start feeding on vertebrates–other fishes, frogs, wildfowl and even small mammals when available. The wels normally hides among weeds during the day but comes out to hunt at dusk and dawn.

Bullhead catfishes A few species of the Ictaluridae or North American catfishes (also called bullheads) have been introduced to Britain. They are native to rich lakes and ponds in North and Central America. There are five genera, with some 25 species, all of them restricted to the New World except for the few species introduced to a variety of other countries.

The body of a bullhead catfish is elongated and scaleless, with a flattened head bearing eight long barbels. There is a well-developed fleshy adipose fin between the dorsal and tail fins, and the dorsal and pectoral fins are armed with strong, sharp spines.

British introductions Several species of bullhead catfishes have been introduced to European waters, notably the black bullhead, the brown bullhead and the channel catfish. Both the former species are established on the European mainland and several introductions have been attempted in the British Isles–with varying success.

The brown and black bullheads have usually been imported as aquarium and pond fishes, and many black bullheads have obviously been released into the wild, for specimens have been recorded from about 50 localities in England, as well as from waters in Mull, Fife and Ayrshire in Scotland. Quite recently 100 specimens of the channel catfish were imported and released in waters in Surrey–apparently for the benefit of anglers. The black bullhead has formed several breeding populations in England and it is quite likely that, in view of their success in other parts of Europe, other species of catfishes will become established here in due course–especially since anglers are keen to introduce new species.

Concern about catfishes The value of introducing these catfishes, including the wels, to British waters is debatable. It is certainly true that the British fish fauna is impoverished compared to that of many other countries, and that new species add diversity. Yet it is never possible to say exactly what effect the introduction of new species may have on animals and plants already in the habitat. Some people are concerned that the wels may be affecting the numbers of several of our native fishes. However, there is no evidence as yet that any native species are being eliminated.

Below: A close-up view of the head of the black bullhead. You can see why catfishes have been given their name–their long barbels bear a distinct resemblance to the whiskers of a cat.

LIFE ON PERILOUS SCREE SLOPES

Scree slopes – banks of loose, bare stones where living things could at any moment be buried by rock falls – may seem barren. Yet, although they are not rich in species, they do in fact support their own range of animals and plants.

Many mountainsides exposed to weathering have broken into vertical cliffs whose loosened fragments are scattered down the slopes below by the force of gravity. Such spreads of disintegrated rock are known as scree or, less commonly, talus. They are common in upland districts and contribute greatly to the wildness of the landscape.

Types of scree Typically, the stones of a scree are sharp and angular, not rounded like those worn by water. Many screes begin at the top of a gully in the cliffs and broaden gradually as they stretch down the slope. Often there are many screes side by side and, although they start as separate streams of stones, they merge into each other lower down to form one large spread of scree.

Most cliffs and screes are found on the north and east sides of our mountains because there they are most exposed to frost. There are several types of screes. They can be of small stones, huge blocks or any size in between. Some screes are steeper than others, but usually they are not extremely steep since, over the years, the stones work their way down to accumulate at lower levels, thus making the slope less severe and more stable. The stones are then said to be lying at an angle of repose. Such screes can usually be walked across, but seldom with any comfort because the stones either move under your feet or are so big that they have to be scrambled over. Screes composed of thin, flat slates are very loose and almost impossible to walk across.

Primary plant colonization Vegetation colonizes screes only very slowly. First come those strange plants, the lichens, each a union of an alga with a fungus. Extremely hardy, they can grow on bare, exposed surfaces at high altitudes; as they cling to the rock they help to wear it away by producing acids which slowly eat into it, gradually crumbling it to form the soil needed by the next colonizers – the mosses. Meanwhile, the frost and other agents of erosion (sun, wind and rain) are also attacking the scree, slowly breaking it down to form soil between the stones. If the parent rock in the cliffs is soft and rotten, then soil forms comparatively quickly, but in screes of hard rock this process is very slow.

Above: Steep scree slopes plunging into the south-east edge of Lake Wastwater in the Lake District. Although screes like this are too unstable a habitat for most plants and animals, they are successfully colonized by a small number of particularly adaptable species. From a conservation point of view, scree is of special value because it is one of the few surviving types of habitat to have been left relatively undisturbed by man. It can therefore be classed along with mountain cliffs and corrie lakes as an almost natural—and therefore precious—element in the mountain scene.

Opposite left: This scree slope (on Ben Lomond in Scotland) is fairly stable, as can be seen from the grasses and other vegetation growing among the stones.

Left: Since most of the rocks in Britain are lacking in calcium, the plants found on scree formed from these rocks are calcifuges—lime-haters. One such plant is this bell heather, a typical scree colonizer.

Right: Few birds frequent screes, but the wheatear is one that may site its nest under the stones.

One of the commonest and most conspicuous mosses of some screes is the woolly hair-moss, which forms large grey-green cushions or even spreads as a continuous carpet visible from far away. As soil and humus begin to gather in screes, then the first flowering plants and ferns become established. These pioneers in their turn add to the soil by the annual dying down and decaying of their leaves and stems. So, in the course of time, if conditions are right, these larger plants may succeed in covering a whole scree so completely that from a distance it ceases to look like a scree at all.

Advantages of scree life What is it that enables some plants to colonize a scree slope despite the obvious disadvantages? First, the very fact that it is too harsh a place for most species means that there is less competition to grow in a scree than in most other habitats; therefore it is open to colonization by adaptable, aggressive plants.

Another virtue of screes is their usually excellent drainage, which ensures that constantly renewed supplies of perhaps mineral-rich water are reaching the roots of the plants. Yet another advantage of good drainage is that there is little danger of the root-rot that afflicts many plants in stagnant water. With their rapid run-off of water it might be thought that screes must suffer from drought, and indeed this may be true of those with southern aspects. But the rainfall in our mountains is so great (usually between 2540-5080mm/100-200in a year) that most screes remain perennially watered, especially those on the shadowy sides of the uplands.

Calcifuges and calcicoles What plants you find on a scree is largely dictated by the chemical content of the rock. Because most of the rocks of British mountains lack calcium (lime) it follows that most of our screes are colonized by plants which can manage with very little or no lime at their roots.

Typical of these calcifuges (lime-haters) are bilberry, common heather, bell heather, crowberry, cowberry, wood-sorrel and heath bedstraw. On some mountainsides the screes are patched bright green with parsley fern, but this elegant plant is strangely absent from other screes that seem to be perfectly suitable for it. Several kinds of upland grasses, such as sheep's fescue, wavy hair-grass and sweet vernal-grass, are common invaders of acid screes. More local are the beech fern, oak fern, bladder fern, sea campion and many others.

Screes which form from the decay of lime-rich cliffs are naturally lime-rich themselves and become a habitat for some lime-loving plants (calcicoles). So, instead of the bilberry, heather and parsley fern of acid ground, these calcareous screes are occupied by mossy saxifrage, yellow saxifrage, alpine willow-herb, alpine scurvygrass, mountain sorrel,

spring sandwort, butterwort and others. Some of these fall on to the scree from the cliffs when the rocks give way. Others may simply slide off a sloping ledge when the soil in which they are growing becomes sodden with heavy rain.

Strip vegetation Where scree covers a whole mountainside, it is unlikely to be uniformly stable. More often it exists as alternating vertical bands of firm and loose material. The loose strips are usually those below gullies in the cliffs because that is where erosion is proceeding briskly and sending down a constantly renewed stream of rock fragments and other debris.

The stable screes, on the other hand, normally lie below cliffs which are more resistant to the weather and therefore produce less scree debris. Or, in some places, a stable strip may lie not below a cliff but under some great detached boulder that has slipped half-way down the slope but then become stuck. There it acts as a brake on the downsliding of the scree, so creating a stable strip immediately below. Because vegetation can form only on stable scree, what we often see on a scree slope are plants growing in vertical lines separated by strips of loose scree with no vegetation at all.

Block scree The coarsest type of scree consists of huge boulders that may be several metres across. They are often the result of rocks splitting off cliffs weakened by cracks. Because these huge masses of detached rock usually slide or roll all the way down the slope, block scree is typically found towards the bottom of a mountainside, and there it may cover a large area. Some block scree at high altitudes is poor in plant life, except for lichens, because its hard surfaces are so exposed to the drying effects of wind and sun. But in shaded corries where there is perennial moisture, the block scree can become overgrown by some of the plants that flourish in the cliffs above.

Deep among the boulders of a block scree you may discover quite a different sort of habitat from that of the open mountainside–a sheltered, shadowy world where mosses and liverworts thrive in abundance and where the accumulation of humus is deep enough for some of the larger ferns more typical of damp, shady woods–lady fern, male fern and broad buckler for example. Some block scree is draped with thick mats of juniper.

Right: In the relatively few areas in Britain where the rocks are lime-rich, a variety of calcicole plants–lime-lovers–can be found. They include this attractive alpine willowherb with its reddish-purple flowers, red sepals and pinkish seeds pods. It is usually to be found in wet places on mountains and flowers in July and August. Other calcicoles on screes are mountain sorrel, alpine scurvygrass and spring sandwort.

Above: Yellow mountain saxifrage flourishing amid large scree boulders on the side of a mountain. It flowers from June to September in wet areas.

Below: Strange though it may seem, a few mammals frequent areas of scree. Block scree, in particular, provides excellent hiding places for foxes during the day. They emerge at nightfall to hunt across the high grasslands and bogs.

Woodland on scree On screes, as on all slopes, such nutrients as the soil contains are always being carried downhill by water. The result is that there is usually more fertility and vegetation on the lower parts of a scree than higher up. Below about 400-430m (1300-1400ft) which, in many districts, is the natural tree line, scree may be covered by woodland which is suppressed on neighbouring grassland by the nibbling of sheep. Although most scree is accessible to sheep, it is far less attractive to them than grassland, and under such light grazing pressure it is frequently possible for woodland to develop.

High-level woodland colonizing limeless block scree usually consists of oak with a scattering of birch, rowan and holly. The trees are mostly wind-stunted and their trunks and branches are adorned with mosses and polypody ferns. The boulders under the trees are green with mosses, leaving little room for flowering plants. Animal life is scanty compared with that of lowland woods. Well-known upland oakwoods on block scree are the Keskadale and Birkrigg Oaks in the Lake District and Wistman's Wood on Dartmoor.

Woodland has also developed locally on upland scree whose rocks are lime-rich. The

dominant tree here is usually ash, with perhaps a mixture of whitebeams and yews. There may be a rich ground flora of calcicole plants, such as lily-of-the-valley, green hellebore, herb paris and spurge laurel. Such ashwoods are well known in parts of the Lake District, the Peak District and Wales on the carboniferous limestone, but they are also found on other lime-rich screes – on igneous rocks, for instance.

Animals of scree slopes A stable scree well clothed with plants provides food and shelter for invertebrates such as centipedes, woodlice, spiders and beetles – all animals which can avoid the worst of the winter weather by withdrawing deep among the stones.

Block scree is also an excellent retreat for such mammals as the stoat, weasel, polecat, pine marten and fox. They lie up by day in the caverns under the rocks and come out at nightfall to forage across the high grasslands and bogs. They prey on rabbits, hares, mice, voles and a variety of small birds and their eggs. Being highly mobile animals, they are not, of course, restricted to the scree habitat alone, and range far and wide.

The birds of screes are few and far between, most typical being the wheatear. This bird uses the tops of rocks as look-out posts from where it can spot its invertebrate prey. It also hides its nest safely out of harm's way under the scree stones. Ring ouzels, too, often forage on screes that lie below the heathery gullies where they breed.

Highly characteristic of block scree is the wren, which spends much of its day down among the great boulders, living on insects, spiders and other small creatures. Its loud, shrill song (unusual for such a small bird) can be quite startling when it suddenly breaks the silence of a mountain scree.

The only other widespread frequenter of screes is the meadow pipit. It often feeds and nests on screes, especially those with plenty of vegetation. High-level screes on some Scottish mountains are an important part of the tundra-like world of the hardy ptarmigan, one of the few birds in Britain that changes in colour from brown in summer to white in winter.

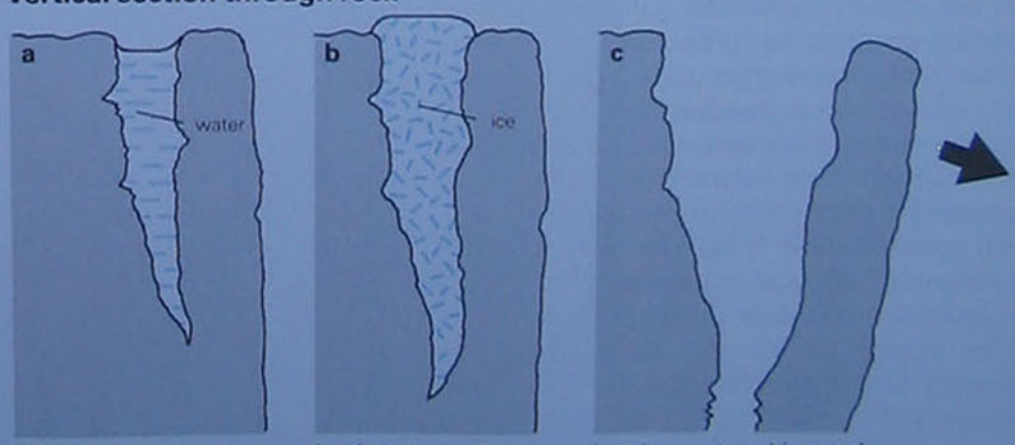
Above: Parsley fern on steep, slaty scree. On some scree slopes this plant forms bright green patches, but on others it is strangely absent.

Right: A view of Llanberis Pass in Snowdonia, with highly mobile, unstable scree on the right. This type of scree is very dangerous to walk on – once the small, loose stones start sliding, they may well precipitate a tumbling avalanche.
Often many screes exist side by side and, although they start as separate streams of stones, they merge into each other lower down the slope to form one large spread of loose stones and debris. Some cliffs shatter to form screes composed entirely of thin, flat slates; these make the loosest of all screes and can be almost impossible to walk across (like the spoil heaps of slate quarries).

The action of frost on rock

Mountain summits are under constant attack by the process of weathering, one of whose most penetrating weapons is frost. Most of the rock of our mountains has been deeply fissured by pressures in the earth's crust. Rainwater trickles down into these cracks (**a**) and, in winter, freezes hard. Then, because ice expands as it forms (**b**), the cracks open slightly. Next winter they open a little more and this frost action, repeated year after year, eventually causes the rock to split (**c**). Cliffs subjected to this type of weathering break into loosened fragments that are scattered down the slopes in the form of scree.

vertical section through rock



rain water fills crack

ice forms, enlarging crack slightly

ice thaws, breaking rock into fragments

Above: The plaintive, bell-like calls of the golden plover are one of the most evocative sounds of our upland heathery hills and moors in the summer.

UPLAND PLOVERS

Three wading birds famous for the beauty of their plumage can be seen in Britain at different times of the year. They are the dotterel and the grey and the golden plovers.

The dotterel and the grey and golden plovers are closely related, showing the classic characteristics of the plover family. They are small, plump-bodied wading birds with short legs. Silent by nature for much of the year, they are solitary (or loosely colonial) on their breeding grounds but gregarious on passage and on their wintering grounds. They frequent areas of open mud, tundra or short turf, for they are not probing birds like most waders, but find their food by surface feeding, running quickly over short distances and picking small invertebrates from the bare ground; they are also adept at extracting earthworms or ragworms with their short bills.

The ringed plover and the lapwing are probably the most familiar British representatives of the family, but the dotterel and the grey and golden plovers are notable for their extraordinary migrations, beautiful plumage and the aura of discreet mystery that surrounds them – probably engendered by the wild and remote places to which they resort for breeding.

Seasonal movements The dotterel is a migrant and rare summer visiting bird in Britain; a few arrive each year to breed on our desolate northern mountain-tops and fells, but most just pass through to winter in the Mediterranean basin and as far east as the Persian Gulf.

There are two races of golden plover; our own breeding population (the southern race) is resident here all year round, nesting on the lonely moorlands of northern Britain. The northern race, distinguished by certain plumage differences, is an uncommon migrant and also a winter visitor to Britain and Ireland; it breeds in Iceland, northern Scandinavia and Russia.

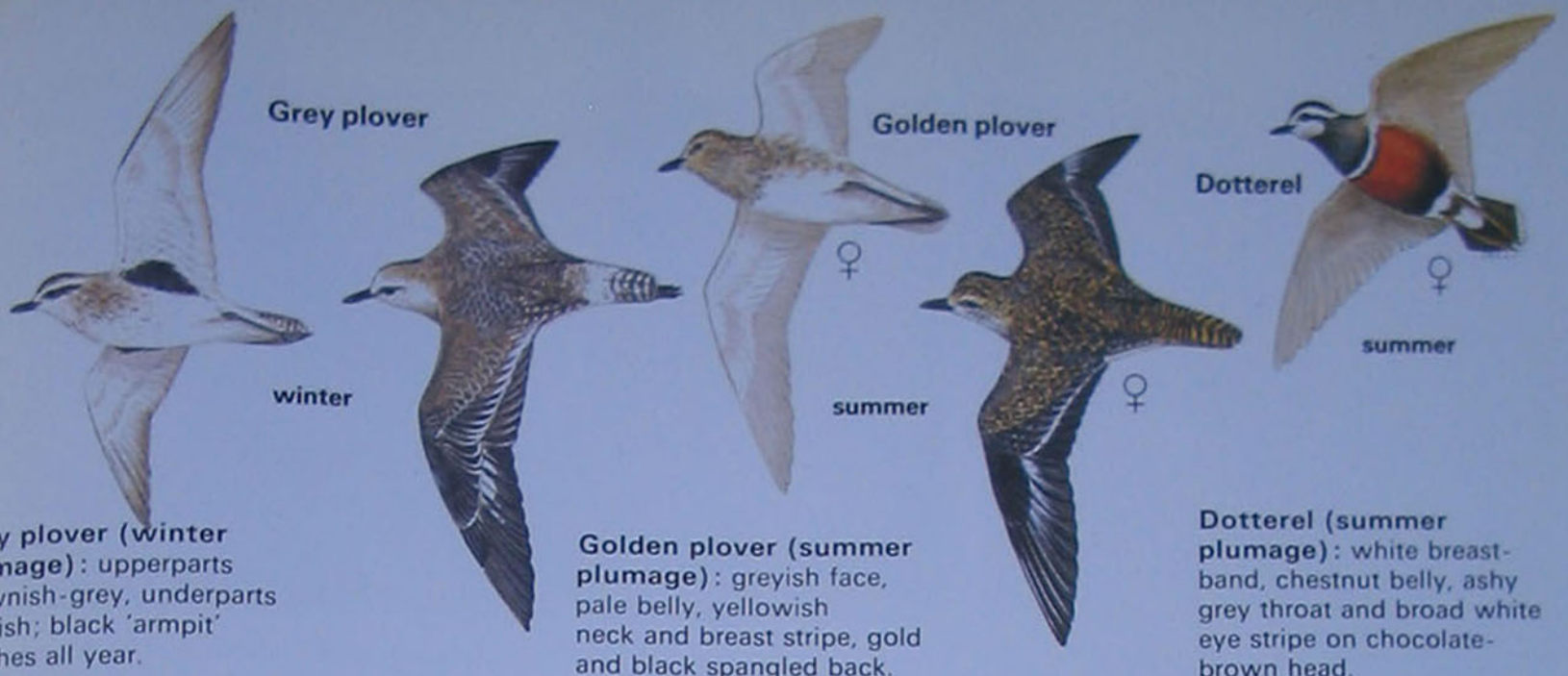
The grey plover, breeding in high latitudes on the coastal tundra of the Arctic basin, is a passage migrant and winter visitor to Britain, moving south in late summer to the shores of every Continent; few suitable coastlines throughout the world do not see grey plovers at some time or another.

Spectacular summer plumage The grey plover (or silver plover as it is more evocatively called in Europe) and the golden plover are similar in size and shape, but with the obvious difference of their silver and gold colourings. In their full breeding plumage both are magnificent birds, with jet black bellies and throats edged broadly with white. The golden plover is spangled with gold and black speckles on the upperparts, the grey plover with silver and black. When the sunlight catches their backs as they move, the gleaming of the golden-yellow and silver-grey is like a surface of jewelled droplets.

In autumn and winter the birds lose their black underparts, but the spangled upperparts still distinguish them from each other. They are also easily separated by the fact that the grey plover feeds exclusively on intertidal

Opposite right: The dotterel in autumn plumage. Autumn is a good time to see these rare birds here as they pass on to southern Europe.

Below: The few breeding pairs of dotterel in the British Isles are protected under the Wildlife and Countryside Act.



Grey plover (winter plumage): upperparts brownish-grey, underparts whitish; black 'armpit' patches all year.

Golden plover (summer plumage): greyish face, pale belly, yellowish neck and breast stripe, gold and black spangled back.

Dotterel (summer plumage): white breast-band, chestnut belly, ashy grey throat and broad white eye stripe on chocolate-brown head.

mudflats around our shores while the golden plover frequents lowland fields and marshes.

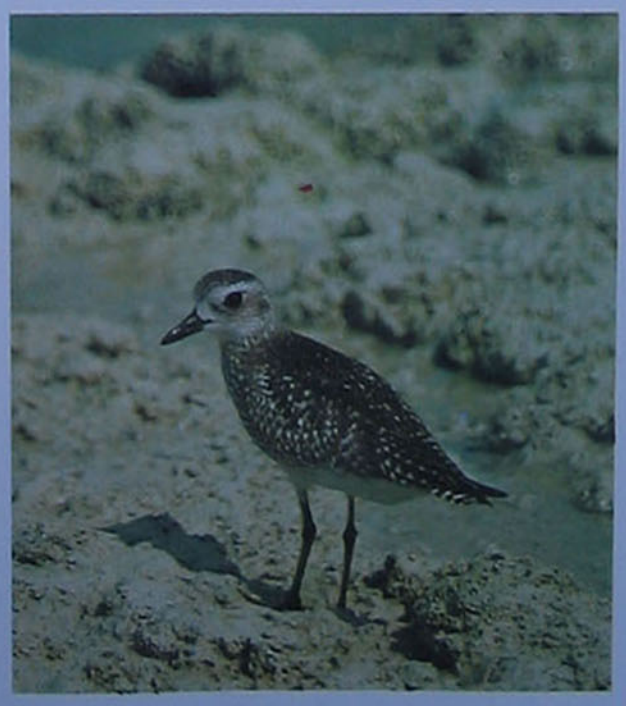
Different dotterels The dotterel, so similar to the golden and grey plovers in shape, flight and feeding methods, is wholly different in other ways. In breeding plumage it is a striking bird, not to be confused with any other. Bold white eye-stripes meeting at the back of the neck in a narrow V separate the chocolate-coloured crown from the ashy grey throat and upper back. Another narrow ribbon of white separates the grey throat from the bright chestnut breast; when the birds are moving fast over the mountain mosses and lichens on their bright yellow legs they are conspicuous, but they blend with the terrain as soon as they stop moving.

The female is slightly larger than the male and has distinctly brighter plumage–clues which alert one to the fact that in this species many of the sexual roles are reversed, with the male caring for the young while the hen produces a second brood from a mating with another male. This male in turn incubates the eggs. So fixed are these roles that the cock regularly drives away the hen if she approaches the unfledged young, probably ensuring that the chicks do not suffer unnecessary competition for food at this crucial stage.

The development of these reversed roles probably derives from the need to free the female from the constraints of nest protection, incubation and brooding so as to maximise her opportunity for producing and replacing eggs in the short, harsh mountain-top environment.

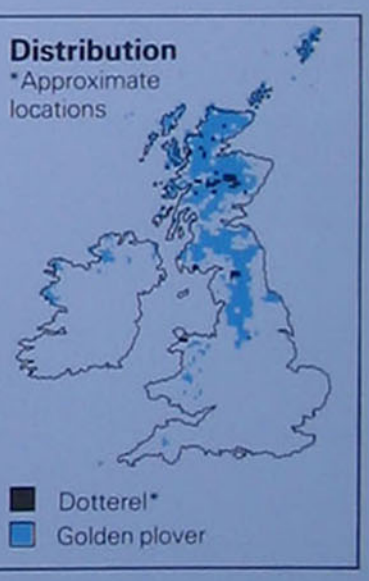
In the British Isles only the highest mountain-tops, notably the Cairngorms in Scotland, support small breeding populations of dotterel. From time to time a few pairs try to nest in Snowdonia and the Lake District, but the whole British population never rises above more than 60 or 70 pairs a year.

The plover breeding season In spring, as the grey plovers leave Britain for the far north, heading for the narrow coastal band of tundra



A beautiful baby

The golden plover chick has golden-yellow and black speckled upperparts. Tended by both parents, it stays in the nest for a month.



Grey plover (*Pluvialis squatarola*). Passage migrant and winter visitor to our coasts and estuaries. Length 28cm (11in).

Left: Between ten and twelve thousand grey plovers winter in the British Isles.

on the shores of the Arctic Ocean, the golden plovers are also on the move. Our resident golden plovers re-populate the hills and moors of upland Britain, while the northern race aim for Iceland and Scandinavia.

From April to July the cries of our breeding golden plovers can be heard on the hills. Their eggs–buff, with blotchy dark brown markings–are laid on the ground in a clutch of four, perfectly camouflaged against the dark heather stems and peaty soil. The golden-brown chicks, which hatch after about four weeks, are among the most beautiful in the world.

Golden plovers share their upland home with only a few other bird species–red grouse, the ubiquitous meadow pipits and skylarks, scavenging crows and ravens, and the ever-present predatory peregrine, merlin and hen harrier. The other principal wader which keeps them company on the rolling moorlands is the small, dapper dunlin–a companion so constant that it has earned the nick-name of 'plover's page'.

Much further north, the grey plovers arrive singly on their breeding grounds, strangely ignoring the vast wastes of Greenland and Spitzbergen which seem perfectly suitable, to breed only on the moorland coastal tundras of Arctic Canada, Alaska and Siberia. Here, as winter retreats and the short intense beauty of the Arctic summer bursts, the grey plovers pair, mate, nest and rear their young. They cannot linger; time is short and each year may present difficulties. In a season when the thaw is too late or conditions bad, breeding may be an impossibility and the adults will return south early. Even in a good year a second brood is out of the question.

Above: The southern form of the golden plover, which breeds here; it is joined in winter by the northern race from Iceland and Scandinavia.

Golden plover (*Pluvialis apricaria*). Resident (southern race) and winter visitor (northern race). Nests on hills, moorland. Length 28cm (11in).

Dotterel (*Eudromias morinellus*). Migrant and rare summer breeding visitor. Length 21cm (8½in).

Above left: The male dotterel's distraction display, aimed at drawing attention away from the nest and chicks. The male bird looks after the young. In the picture below a male is carefully turning over the eggs.

Winter populations Autumn brings all three different plovers on passage through the British Isles. The dotterel, small 'trips' of them faithfully stopping on traditional resting sites on mountain-tops, headlands or lowland fields, pass on southwards. The grey plovers, hugging the coastlines of western Europe, spread themselves over favoured estuaries, and the golden plovers distribute themselves on inland and coastal pastures.

Our own breeding golden plovers (the southern race) are joined by those from Iceland and Scandinavia. These northern birds have bolder, more extensive black bellies once the breeding plumage develops in late winter. The total number of golden plover wintering here is probably 400,000 or more, 15% of them on estuary marshes and the remainder inland. Any congregation of lapwings seen in fields at this time of year is worth checking for the presence of the dumpy, less conspicuous forms of golden plover among them.

Although many golden plover are present in winter, they are a declining and contracting breeding species on the southern fringes of their range in Britain and Continental Europe. This is probably due to habitat loss.

Above: Gannets greet each other with raised bills.

GANNETS: PLUNGING DIVERS OF THE SEA

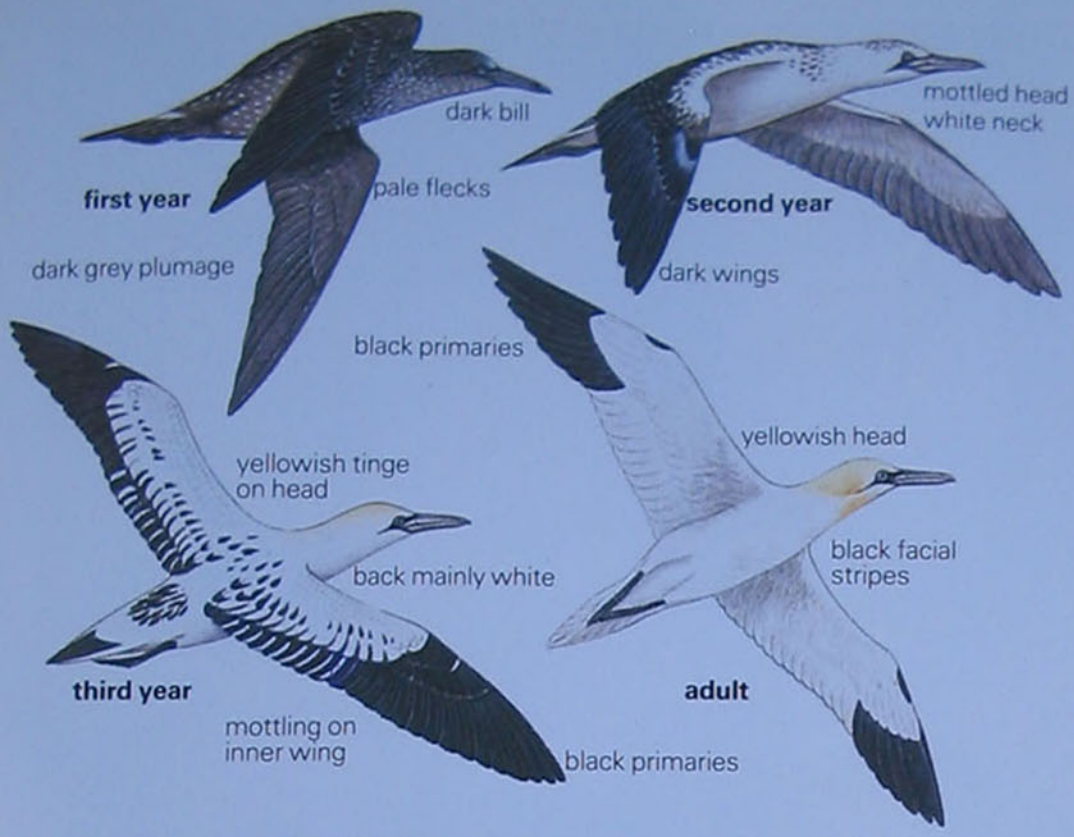
A gannetry in spring or summer is a breathtaking spectacle: the cliffs and rocks are white with many thousands of these large seabirds. The air, too, is filled with gannets in soaring flight, each ready to plunge into the sea for fish, perhaps from a height of 30m (100ft) or more.

The gannet is our biggest and most spectacular seabird, with a body length of about 1m (3ft) and a wingspan approaching 2m (over 6ft). It is essentially a maritime bird, breeding in cliff colonies called gannetries, although very occasionally storm-driven gannets are seen on lakes and reservoirs inland.

Goose-like bird The adult gannet is a large, almost goose-like white bird with a yellow ochre tinge to the head and nape and conspicuous black wingtips. The yellow colour is mostly lost in winter. In flight, its appearance is less goose-like, mainly because the stout neck and beak in front are counterbalanced by a long, pointed white tail, whereas geese have very short tails and a characteristically unbalanced appearance in flight. The wings, long and noticeably slender, are white for much of their length but with mostly black primaries, or flight feathers. Gannets are often seen flying along the shore, maintaining a height of about 10m (30ft) above the water. The steady flight pattern consists of a series of slow wingbeats, followed by a glide. In small flocks, often all or most birds will pause to glide with precisely timed synchrony.

Gannetry sites

1 Herma Ness; **2** Noss; **3** Foula; **4** Fair Isle; **5** Sula Sgeir; **6** Sule Stack; **7** Flannans; **8** St Kilda; **9** Bass Rock; **10** Ailsa Craig; **11** Scar Rocks; **12** Bempton; **13** Gt Saltee; **14** Little Skellig; **15** Bull Rock; **16** Grassholm; **17, 18** Alderney.



Gannet (*Sula bassana*). Resident seabird; 70% of world population found in British Isles. Sexes are alike. Length 90cm (36in), wingspan 1.8m (6ft).

Left: A juvenile gannet. In its first autumn and winter it is dark chocolate brown, flecked with pale grey or white. The plumage develops to the adult stage over four or five years.

Below: Herma Ness gannetry, at the extreme northern tip of Shetland.

In close-up view when perched, the gannet's webbed feet can be seen to be lead grey, with a neat blue-grey line running along each toe and down the front of the 'shin' or tarsus. The beak, stout and dagger-like, is almost 15cm (6in) long, and is silver coloured, with black lines. On the face a patch of grey or bluish naked skin surrounds a glaring eye with a strikingly pale iris.

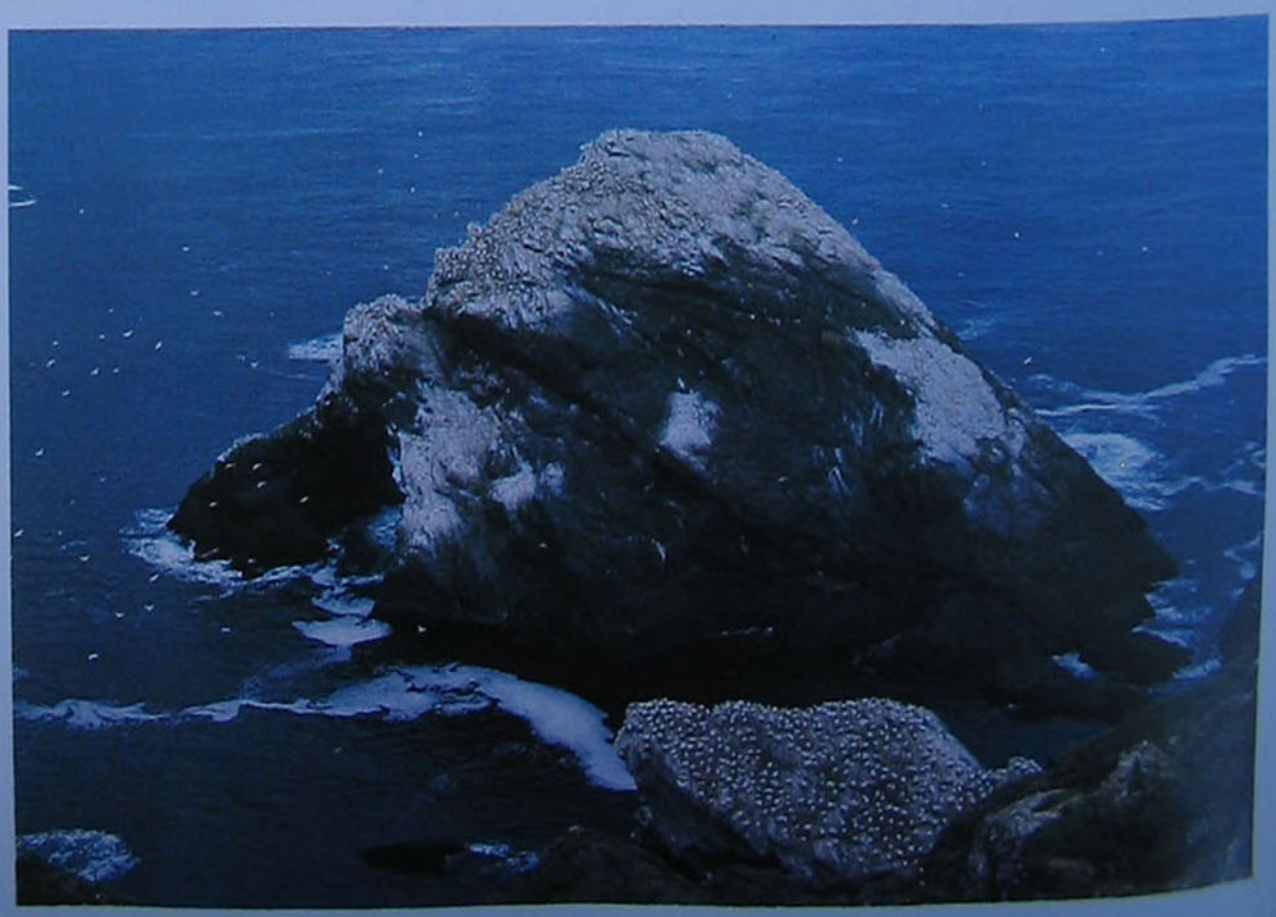
Remote gannetries Gannets are colonial breeders, and their expansion in numbers over the last hundred years is one of the more striking bird success stories. There are now 18 gannetries off our coasts, no less than 11 of them founded this century.

The current increase in gannet numbers may partly be a restoration to an earlier situation following an intervening decline. Certainly during the 18th and 19th centuries gannets were persecuted by man, the fat and nutritious nestlings being slaughtered for food in tens of thousands by the inhabitants of some of our remote islands. This pressure has ended with the modernisation of our food industry, and with bird protection laws.

At the same time, it seems most unlikely that the current rate of increase, some 3% per annum, can be solely due to the relaxation of hunting pressure. Probably a major additional factor is climatic change, influencing the numbers and location of such surface-shoaling fish as mackerel, on which the gannets feed. Certainly the rate of increase is high for such a large bird which lays only one egg per season.

During the present century, the world population of the gannet has trebled, and with some 140,000 breeding pairs, Britain and Ireland hold 70% of the world total. Perhaps as many as one third of the world total now

Diving for a fish



nests on Boreray and its associated giant rock pinnacles, Stac Lee and Stac-an-Armin, which form part of the St Kilda group of islands. This gannetry may hold over 60,000 pairs. Calculations of the daily catch of fish when the Boreray colony is fully occupied in spring and summer indicate that a prodigious 200 tons or more of fish a day are needed to supply it.

Adapted to fishing In the vicinity of a gannetry, the birds are seen performing their fishing plunge, often from a height of 30m (100ft) or more. When fish are present in huge numbers close to the surface, or when the weather is particularly rough, making visibility poor, the gannets sometimes dive at a slant into the water from a height of only a few feet.

Anatomically, the gannet is admirably well adapted to this way of life. Its eyes, for example, can swivel freely in the sockets, enabling the gannet to look vertically down into the water while maintaining its head in a horizontal position for good aerodynamic 'trim'. Feathers and tough skin assist a robust skeleton in resisting the impact of high dives, and the eyes are set in sockets lined with special 'padding' tissue which acts as a shock absorber.

Gannets differ from sea eagles, ospreys and other dive-plunging birds in the position of their wings during the dive. Instead of entering the water with their wings bent, the 'elbow' pointing forward, gannets allow their wings to trail, stretched out alongside and behind the tail as they penetrate the surface.

The food of the gannet consists almost entirely of fish, the choice depending more on easy availability than on any particular preference. Mackerel, herring, cod, capelin, saithe and pollack all feature regularly in the diet. Most food items are swallowed with a convulsive gulp just as the gannet surfaces from its dive, and can often be seen as a large bulge, steadily descending the gullet.

Colonial breeding Adult gannets begin to return to their nesting ledges in late winter, and by the spring noisy honking displays are commonplace; pairs alternately raise and lower their bills to one another in a complex and ritualised pattern. Gannets are monogamous, and usually pair for life (which is on average about 16 years), although the two sexes go their separate ways during the winter.

Over the years, most nests have become substantial mounds of seaweed and flotsam, held together with guano. As part of the courtship ritual, the male brings frequent 'gifts' of seaweed to the female on the nest, which helps it to become even bigger. The single egg is relatively small for the size of the adult bird, being 7.5cm (3in) long and 5cm (2in) broad. It is chalky blue when laid, but rapidly becomes stained brown. Some eggs are lost to predators such as gulls, or by rolling off the nest (usually during a squabble with the neighbours), but in a study of the gannets on Bass Rock it was found that over 80% hatched. Eggs lost in the first three weeks of incubation are usually replaced.

Gannets in winter Once they leave the breeding colonies at the end of summer, adult and young gannets separate to go their own way during the winter. The adults, with their superior skills at fishing in poor conditions gained over several seasons, disperse from the colonies but tend to remain in coastal waters round Britain and Ireland or slightly to the south, rarely travelling further than Portugal or Spain. The young birds of the year, on the other hand, migrate purposefully south, first to the Bay of Biscay and later to the waters off North and West Africa.

Above: Over 10,000 pairs of gannets breed each year on the Bass Rock, off the coast of Lothian.

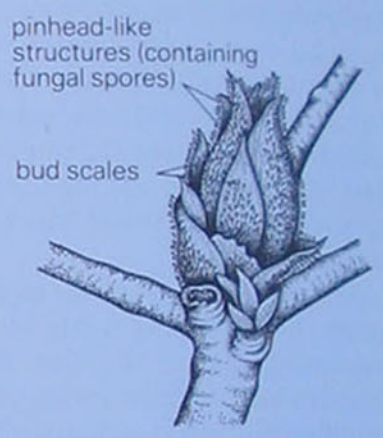
Below: A gannet incubating its egg. The bird has no brood patch of bare skin on the belly to warm the eggs, but instead laps the webs of its feet over the egg to warm it. Incubation takes about 45 days—the longest time for any bird of Britain and Ireland. Fledging takes about 90 days, so there is time for only a single brood each summer.

LEAF-HOPPERS AND TREE-HOPPERS

In summer and autumn you may well see small insects leaping about on plants. They belong to the leaf-hopper family–some species are pests but the majority are harmless and remarkably attractive.

Left: The colourful rhododendron leaf-hopper (*Graphocephala fennahi*) jumps from leaf to leaf using its wings to assist its movement through the air. Leaf-hoppers need to warm up before they can fly –if you disturb one early in the morning, when it is still cold and can only hop, its jump may measure only 30cm (1ft), yet later on in the day, when it is warmer and can combine its leap with its flight, it may cover 1-3m (3-9ft) at a time. Notice the long hind legs with a row of spines along the length–they provide the power for leaping.

Bud blast



Above: The fungal disease, bud blast, is associated with leaf-hoppers as it is thought that the spores infect buds which have been damaged by leaf-hoppers. The symptoms of this disease are tiny black pinhead-like structures growing on the surface of the bud in spring–the affected buds never open.

Several kinds of hopping insects may be found feeding on the sap of plants in summer and autumn. Although frog-hoppers (the insects that produce cuckoo spit) are the largest and most noticeable, the majority belong to another group of insects–the leaf-hopper family (Cicadellidae). These in turn, are members of the insect order Hemiptera, or true bugs, which are characterised by their sucking and piercing beak-like mouthparts. Two hundred and fifty species of leaf-hopper exist in Britain.

Striking beauty The rhododendron leaf-hopper is one of the largest and most common species. Although it is now abundant more or less wherever rhododendrons grow in southern and central England it is, in fact, an introduced species from North America, and was first recorded here in 1936.

If you approach a rhododendron bush in the summer you are sure to see this species on the leaves. It usually sits with its head pointing upwards, and is extremely wary, so that when you approach it either runs beneath the leaf or leaps and flies away.

The rhododendron leaf-hopper is brilliantly coloured, being green, red, yellow and black. Its wings are green with longitudinal red stripes margined with yellow, while the rest of the body is clear yellow.

Life-cycle The females lay up to 300 eggs in late summer and autumn in shallow slits–which they cut with the blades of their ovipositors–in the outer protective scales of next year's rhododendron flower buds. The eggs overwinter and in April hatch into nymphs which resemble small, pale yellowish-green adults without wings. Like the adults they feed on sap from the undersides of leaves.

The nymphs cast their skins five times before becoming adults, the wings starting to appear on adults towards the end of July: being long-lived, they continue to be seen until the cold weather sets in, sometimes as late as the second or third week in October.

Leaf-hopper species The largest of our leaf-hoppers is the eared leaf-hopper (the name derives from the thin ear-like projections on the upper surface of its thorax). It is a flat-

Below: Rhododendron leaf-hoppers sit on plants, usually with their heads pointing upwards.

Above: Eared leaf-hopper (*Ledra aurita*), 13-18mm (½-¾in) long. Found in woods in southern England.

Above: Rose leaf-hopper (*Edwardsiana rosea*), 6-8mm (¼in) long. Occurs on rose bushes and fruit trees.

Above: Strawberry leaf-hopper (*Aphrodes bicinctus*), 5-7mm (¼-⅓in) long. Found on cultivated plants.

Above: Broom tree-hopper (*Gargara genistae*), 5mm (¼in) long. Found on broom in south-east England.

tened insect with mottled colours which blend well with the lichen-covered branches of oak trees, on which both the adults and the nymphs live. It is found from May to September in woods in the southern half of England.

The green leaf-hopper is common on grasses and rushes in marshy places throughout the British Isles from July to October. Another species, the rose leaf-hopper, is a tiny pale yellowish insect that occurs on a variety of bushes and trees but is most frequently seen on rose, apple and cherry trees and hawthorn bushes. There are two generations a year, the eggs of the second generation overwintering in the buds where they are laid in autumn.. Rose leaf-hoppers often damage roses by producing a fine white mottling on the upper leaf surfaces; this can cause the leaves to fall earlier than usual.

Some species that feed naturally on grasses have spread to cultivated plants where they have become serious pests. Examples are the hop leaf-hopper and two strawberry leaf-hoppers, *Aphrodes bicinctus* and *Euscelis lineolatus*. Apart from causing direct damage to plants, the strawberry leaf-hoppers carry green petal disease–a virus which prevents the formation of fruit.

Tree-hopper relative Tree-hoppers belong to the family Membracidae, and are closely related to leaf-hoppers. They are easily recognisable by the backward pointing extension on their thorax which, in tropical species, can look quite bizarre.

Only two species occur in Britain: the horned tree-hopper, which is found all over Britain in woods, particularly on oak, from May to August, and carries two thorn-like processes on its thorax as well as having the backward pointing one; and the broom tree-hopper, which is only found on broom in south-east England, and has a simpler thorax.

Above: The hop leaf-hopper (*Evacanthus interruptus*) measures 5-7mm (¾-⅓in) in length, and has become a serious pest on cultivated plants, particularly hops.

Right: The green leaf-hopper (*Cicadella viridis*), at 6-8mm (¼in), long, occurs in marshy areas throughout the British Isles from July to October. Although its name suggests a greenish colour, its wings may vary from bright green to blue or even purple.

Below: The two thorn-like processes (seen in the picture) on its thorax, give the horned tree-hopper (*Centrotes cornutus*) its common name. At 9mm (⅓in) long, it is found in woodland–especially oak–all over Britain from May to August.

CONGER EELS OF REEFS AND WRECKS

Conger eels lurk in crevices among rocks and reefs, hunting for smaller fishes, cuttlefishes and other marine animals. Wrecks, pier walls and the legs of North Sea oil drilling rigs also provide suitable habitats for this highly adaptable fish.

Above: The conger's method of feeding is one of stealth rather than bold action. Concealed in the half-light within a crevice in the rocks or in a wreck, it waits until unsuspecting prey comes within reach, then with a quick lunge it seizes its victim. The conger takes bottom-living fishes as well as cuttlefishes, octopuses and even crabs. At night, congers tend to leave their hideaways and forage across the open sea-bed. It is then that they are sometimes caught in trawls.

The conger eel is not a familiar fish. Little used for food, it is usually seen only by anglers and divers. It is, however, a common fish all round the coasts of Britain and Ireland, but possibly most abundant where rocks and reefs offer it shelter.

Its preference for rocks means that it is sometimes found on the shore in rock pools and in seaweed-hung crevices near the low tide mark. As it is adept at slipping deep into tiny crevices in the rock, the conger is not easy to catch, but occasionally one emerges as a result of prodding with a stick – a quite frightening experience if one happens to be barefoot, for the eel has a reputation for snapping savagely when cornered.

Two species of eel The two common species of eel in the British Isles are the conger eel and the so-called freshwater eel, which despite its name spends part of its life in the sea. In rock pools and even the shallow pools left by the tide on some sandy beaches, eels of both species are found, and so it is necessary to distinguish between the two. First, look at the jaw and fins. The conger's upper jaw is longer than the lower, while in the freshwater eel the 'chin' juts forward in front of the upper jaw. A conger's pectoral fins are rather pointed, while those of the freshwater eel are rounded, and the conger's dorsal fin begins close behind the head.

Such anatomical details may not, however, be necessary to recognise the eel: size alone may be conclusive evidence. At the stage of their lives when they are found on the shore, freshwater eels are not usually more than 50cm (20in) long, although exceptional specimens of 1m (39in) are caught. If an eel found on the shore is more than 75cm (30in) long, it is almost bound to be a conger, for they rarely occur on the shore under this length.

Hiding places Rocky shores at around low tide mark are an important habitat for young congers, although they are probably as numerous offshore provided there are rocks among which they can hide. Larger congers live in deeper water, but not necessarily very deep water, for specimens up to 2.2kg (5lb) in weight are caught from the shore. They have also adopted man-made 'reefs' (such as breakwaters), and there are few sunken ships or aircraft wrecks which do not have their populations of conger eels.

Prey of the conger The conger's jaws are lined with rows of strong, triangular teeth, as close together as the teeth of a comb. They are relatively unspecialised, leaving the conger

Right: A young conger eel in the shallows.

Below left: A sea angler 'gaffs' a conger–speedily bringing it aboard with a special hook known as a gaff. Gaffs are used in preference to landing nets when there is a danger that the angler might be injured by a large or dangerous fish. The eel seen here is a middle-sized specimen–the species can grow to a length of 2.7m (9ft) and a weight of around 68kg (150lb). The largest conger known to have been caught by an angler weighed nearly 50kg (108lb) and was caught off the Eddystone Reef in 1976. Congers of this size have a girth bigger than a man's thigh and are extremely muscular and active fish. They are also very tenacious of life, and snap boldly in self-defence with their jaws. When encountered in the sea by divers, however, they do not normally attack, despite their size and strength. This contrasts strongly with the moray eel, a far more dangerous fish.

free to feed on both hard and soft bodied creatures. The few observations that have been made on the diet of congers show that they eat large quantities of bottom-living fishes such as rocklings, dogfishes, flatfishes and pollack. Pollack are specially attracted to wrecks. Congers also catch cephalopods such as cuttlefishes and octopuses. Crabs of various kinds, particularly the edible crab, and lobsters, are also eaten by congers.

Atlantic spawning Relatively little is known about the breeding places of the conger, although like the freshwater eel it migrates to distant waters to spawn. The only known spawning area of the conger lies far to the south of Britain, somewhere between Gibraltar and the Azores, where the sea is over 3000m (1640 fathoms) deep. It is believed that all western European congers originate in that area, having developed from eggs shed in mid-summer, probably in the middle depths of the water. The larvae drift near the surface, generally taking a north-easterly course, until at the age of one to two years (depending on the direction in which they have drifted) they reach shallow water and metamorphose into young conger eels.

Congers and man The conger is one of the few fishes to have benefited from man's domination of the natural environment. Man is responsible for the wrecks on the sea-bed, the oil rigs in deep water and the many breakwaters, harbour walls and pier pilings–all of which offer a secure habitat. Some of these, indeed, are in areas such as the southern North Sea and the eastern English Channel, where natural habitats for the conger are scarce.

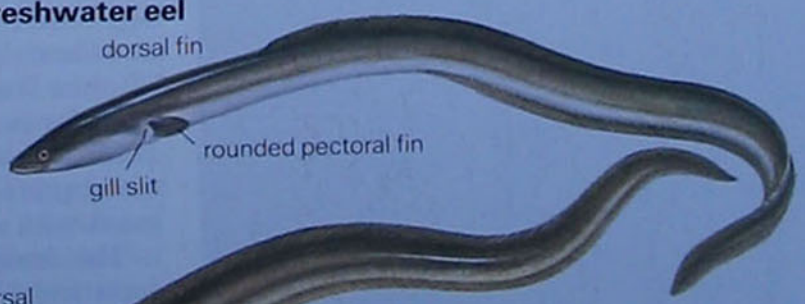
A second factor is that in some harbours fishermen prepare their catch for market on board ship, throwing a considerable amount of offal and fish heads into the water. Conger eels living in the crevices of such harbour walls live well on these remains, although the species as a rule does not scavenge. Thirdly, people do not eat congers as much today as they used to, and therefore serious commercial fishing for them ended many years ago. As a result of all these factors, the conger eel is more abundant now than in the past.

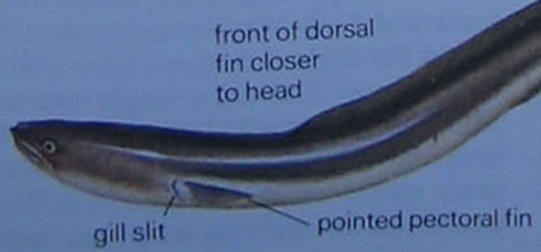
Head of conger eel

Head of freshwater eel

Above: Details of the shape of the head are useful in telling apart our two most common species of eel. Look at the mouth and jaws: the conger's upper jaw is longer than the lower, while the freshwater eel has a jutting chin.

Freshwater eel





Below: The larva of a conger eel. This stage of the life-cycle is followed by the post-larva, which is the first stage of metamorphosis into a young eel. The larva grows to a length of a few centimetres. The post-larva is similar, but larger.

Conger eel larva

THE MAMMALS OF DECIDUOUS WOODS

Although deciduous woods can seem to be uninhabited, tucked away in the different layers of vegetation are many of our mammals, from large badgers and foxes to small mice, shrews and voles. Each has a special niche within this rich environment.

Right: A badger sett at dusk on a summer's evening. Badgers are one of the most common mammals of all types of deciduous woodlands, advertising their presence by evidence of their vigorous digging outside the sett. The best kind of site is one that is well protected—often by elder trees which have grown up from seeds contained in the droppings.

Deciduous woodland supports a greater variety of mammals than any other natural habitat. Many of today's woodlands are remnants of the great broadleaved forest that once stretched across the whole of northern Europe. Two thirds of our deciduous woodland is either native beech or oak, usually combined with species such as birch, ash, hazel, sycamore and various shrubs.

Layered habitats Deciduous woodlands consist of four main layers of vegetation, each providing living space for different species. Some, such as common and pygmy shrews, spend their entire lives at one level; others, such as squirrels and woodmice, move between the layers. Competition for space is not as great as it is in the less complex habitats of fields or moorlands, and many more species are accommodated into the woodland environment.

The highest point is the tree or canopy layer, comprising the branches of mature trees from 6-18m (20-60ft) high or more. Young trees, shrubs and bushes form the next level, the shrub layer, a dense growth sometimes called the lower canopy. Here such species as blackthorn, buckthorn, dog rose, elder, hawthorn and spindle flourish. Below is the field layer which extends to about 2m (6ft) above ground level and consists of low woody and herbaceous plants, flowers, ferns and mosses. This is the richest level in the variety of wildlife it supports, and most woodland mammals live or feed here. Below is the litter and soil layer.

Below: A vixen and her cubs. A vixen will move her cubs to another location if she feels threatened, often taking over an old earth. Many foxes spend days lying up above ground.

Most mammals are more dependent on the general structure of deciduous woodland than on any individual plant species contained there. Important factors are the height of the vegetation, the presence or absence of field and shrub layers, and whether there are areas of open land, scrub and old trees. The bank vole, for example, is most common in woodlands with dense herbaceous areas, while the woodmouse is the common rodent of woodlands with an open field layer.

The canopy This layer attracts mainly insects and birds. Oak trees, in particular, are noted for their rich insect life—well over 200 species may live on a single tree during its life-span of up to 250 years. This activity not only draws numerous birds, but some mammals spend much of their lives high in the branches. Several species of bat hunt around

the tops of trees for flying insects and some, notably the long-eared bat, specialise in picking insects off the foliage. Bats often inhabit holes in the upper reaches of the trunk. In beech woodland during the day you can sometimes hear the noctule bat chattering in a tree hole, and nursery colonies are also found in tree holes.

The most common mammal of the tree canopy of deciduous woodlands is the grey squirrel. It thrives particularly in oak and sweet chestnut woodlands, feeding on nuts, bark (especially that of sycamore), shoots, fungi and birds' eggs. In winter it is quite easy to spot its untidy spherical drey of twigs and dead leaves high in the branches, or at the junction of a branch and the main trunk.

A mammal sometimes confused with the grey squirrel is the fat dormouse, also known as the grey, edible or squirrel-tailed dormouse. It is confined to an area around Tring in the Chilterns, where it was first introduced earlier this century. However, it is smaller than the squirrel and entirely nocturnal, spending its day in a nest built close to the trunk of a tree or in a tree hole. It has a similar diet to the grey squirrel, and can cause damage to trees. Both species are accomplished acrobats, making great leaps between branches, using their tails to help with balance.

The red squirrel has lived in the British Isles for over 9000 years, particularly in the native Scots pine forests of the north. Today it lives mainly in pine woods, but in some parts of the British Isles it has adapted to deciduous woodland, above all to areas containing hazel and oak. Because of its arboreal nature, it has few predators, although it is occasionally pursued by the pine marten in areas of mixed natural woodland in the Scottish Highlands. In general the red squirrel population is declining in deciduous woodlands, although in some areas it co-exists well with the grey squirrel.

Shrub layer This layer consists of the lower branches of mature trees, saplings and shrubs, and it is often entwined with such climbers as ivy or honeysuckle. Indeed, stripped honeysuckle stems are a sign of the presence of the common, or hazel, dormouse, an increasingly rare mammal which lives mainly in the shrub layer, although it also climbs into the canopy. It prefers woodlands with plenty of dense secondary growth and scrub, where hazel, beech and sweet chestnut are the dominant tree species. It makes its daytime roosting nest in the undergrowth or in the cleft of a sapling.

The dormouse is a solitary, nocturnal animal and one of the best times to look out for it is the twilight of late summer and early autumn evenings when it emerges from its daytime sleep to eat all the fruits and nuts it can find so as to gain weight before its long winter hibernation from October to April. One sign of its presence is discarded hazel nuts with smooth, neat, round holes; other rodents leave a more ragged hole.

Deer are creatures of the shrub layer. They remain hidden during most of the day, moving from cover in the evening to graze, and returning at dawn. In undisturbed areas they may be active during the day, but usually all you will see is a disappearing rump as the animal runs off into the trees.

Sika deer have established feral herds in

Below: The stoat lives in most areas of the British Isles but particularly in deciduous woodland where there are good supplies of food. It takes fruits and berries as well as rodents and rabbits. Apart from man, the stoat has no natural predators.

Above: The roe deer is much more conspicuous during winter when its white rump shows up clearly in the bare woodland. It is a browser, preferring bramble and twigs.

Below: A hedgehog with its young in autumn leaves. The hedgehog tends to live on the edge of deciduous woodland, as well as in copses and farmland. Litters may be born as late as October, but the young are unlikely to survive the winter.

Dorset, Hampshire, West Yorkshire and parts of Scotland. They prefer deciduous or mixed woodland with an undergrowth of hazel, bramble, blackthorn or other shrubs. Sika are grazers, feeding mainly on grasses and sedges in fields and open land within easy distance of protective cover.

Roe deer are mainly browsers, taking leaves, branches, shoots and bark of broad-leaved trees including ash, hazel and oak. In many areas they are considered a serious pest. Fallow deer and muntjac are both grazers and browsers, depending on the availability of food. Fallow deer have the widest distribution of all the deer species in England, while muntjac are mainly confined to the south-east.

Lower layers Dwelling in the field layer and at ground level are woodmice, bank voles, shrews, hedgehogs, rabbits and hares, and their predators the fox, stoat, weasel and, in Wales, the polecat. The badger, largest of the woodland mammals, eats small mammals occasionally but its main diet includes amphibians, slugs, snails, grubs, insects and earthworms (probably its most important food item), as well as fruits, roots, tubers and nuts.

Some of these species, such as shrews and bank voles, are active day and night. The common shrew makes runways and tunnels through the litter and soil and can sometimes be heard making a soft twittering sound as it searches for invertebrates to satisfy its voracious appetite. It eats at a furious rate for two hours or so, then rests, and then eats again, for it must take in its own body weight each day. The pygmy shrew also lives in woodlands, but it is less abundant than its relatives. The bank vole builds a nest of grass and moss under roots and in tree stumps. It is an active burrower, but most of its food is obtained from the field layer.

Moles are also both nocturnal and diurnal, although mole hills are likely to be the only evidence of their existence, for adult moles are seldom seen above ground. The mole digs its complex tunnel system underground, pushing the loose soil upwards to form the characteristic molehill. People do not always realise that deciduous woodlands have abundant mole populations because the large nest mound or 'fortress' is usually built in dense

undergrowth.

Of the woodland's mammal predators, the stoat and weasel are the most active during the day. They are mainly ground-level hunters, following regularly revised paths and feeding on locally available small to medium sized mammals such as mice, voles and rabbits.

Night life Towards dusk, when truly diurnal mammals such as the grey squirrel are eating their last meal of the day, a night-shift begins to appear. Bats, including the noctule, pipistrelle, Bechstein's and serotine, emerge from their roosts in tree hollows or beneath foliage in the upper canopy, and can be heard squeaking and chattering as they chase insects, including moths.

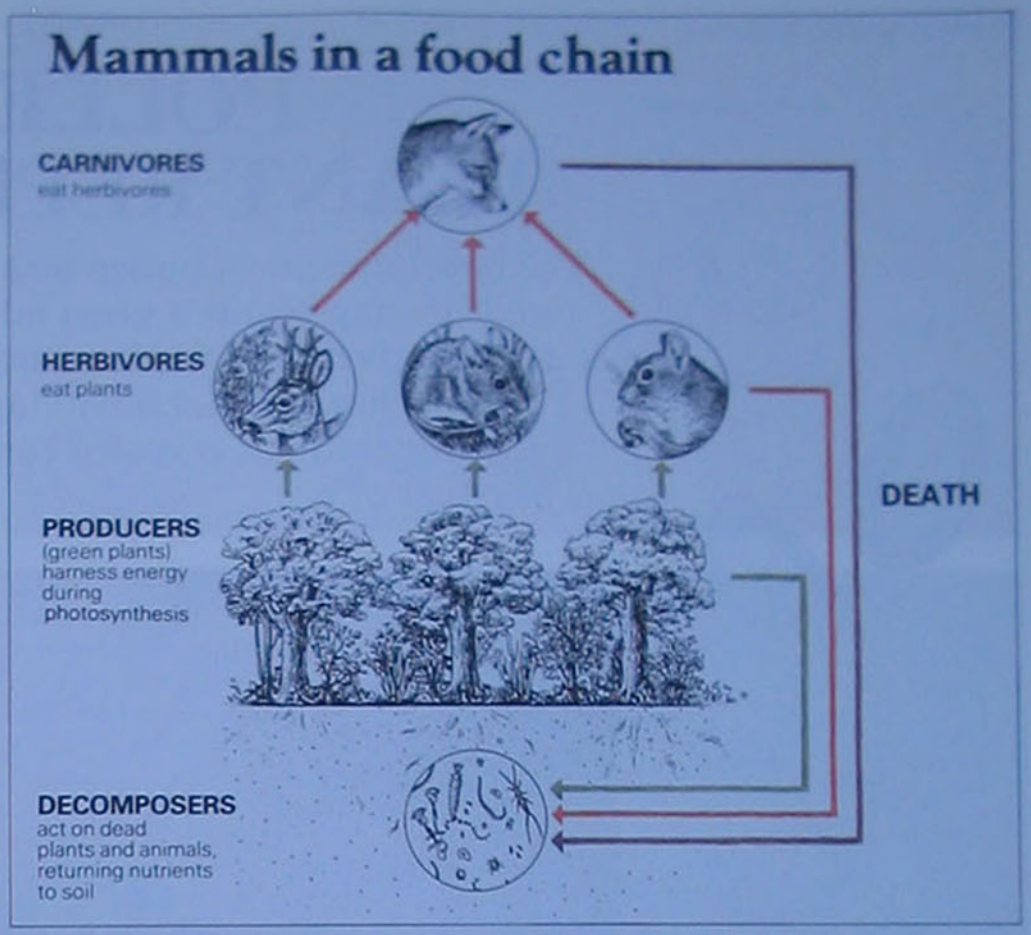
Around dusk the badger emerges from its sett. It has no predators apart from man, and its conspicuous colouring serves as a recognition sign for other badgers at night, although it appears grey from a distance. Its ideal habitat is a beech wood on light, well-drained gravelly soil, with pasture and arable land within its home range, although it is well adapted to all types of deciduous woodland. Another carnivore, the fox, is one of the most successful of all our mammals, managing to live in almost all types of habitat in the British Isles. In woodlands its diet includes small rodents, rabbits, hares, birds, insects and carrion.

The most nocturnal mammals are the hedgehog, fat and common dormouse, woodmouse and yellow-necked mouse. The hedgehog sleeps in undergrowth during the day, changing its site frequently during summer. It searches at night for ground level invertebrates.

Cold weather The deciduous woodland in autumn provides a rich supply of food for its inhabitants. Nuts and pulpy fruits, as well as fungi, are eagerly seized. Even the highly carnivorous fox takes its share. To some species the autumn harvest is of special long-term importance. The grey squirrel stores surplus nuts in the ground, in tree hollows and in dreys. In times of shortage it can remember the general area where the caches lie, but damp conditions are needed before it can locate, by its sense of smell, the exact position of a hoard. Many of these caches remain unused or undiscovered, and the seeds and nuts may germinate to become new trees.

In years of poor mast harvest many mammals, especially those with specialised or restricted diets, such as the edible dormouse, die before their first winter. Many young mammals leave home in autumn, and the available food supply from trees and shrubs can be a vital factor in their survival. Many mammals reduce their activity, but in the British Isles only a few truly hibernate: hedgehogs, bats and the two species of dormouse. The metabolism slows right down, the heart beats much less often, the animal breathes more slowly, and its temperature drops. In this way it conserves its energy. Warm days in mid-winter can be disastrous for hibernating animals, for their body temperature heats up and they use their vital stored energy too fast, with no means of replacing it until spring.

For the deer on the other hand, autumn and winter are the most strenuous period of the year. For the fallow deer, in particular, autumn is the time of the 'rut', a period of tremendous activity for the males, which mark out their territories by fraying trees and shrubs with their antlers and by scraping the leaf litter and soil. Rutting areas, which are usually beneath trees, can be recognised in autumn by the well-trodden paths around the bases and by the musky scent of the bucks.



Below: A mole making an appearance above ground. The mole takes nearly all of its food underground, for worms are its main diet and on a clay soil in a deciduous wood they will often fall into the mole's tunnels. The mole sometimes builds a fortress, an enormous molehill that is usually concealed in the undergrowth. Since it spends most of its time underground the mole is relatively secure from predators, although some are killed by foxes.

POLLEN AND PLANT REPRODUCTION

The development of pollen as a means of reproduction gave the seed-bearing plants a great advantage over the lower plants– it allowed them to colonize much drier habitats. To us, however, pollen has another advantage, for its preservation in the fossil record has revealed much about our past vegetation.

In lower plants, such as mosses, liverworts and ferns, fertilisation is achieved by means of microscopically small male sex cells, the male gametes, swimming through a film of water to reach the female reproductive parts. Without water to act as a medium, these male gametes cannot fertilise the female gametes and so the plants, or at least their sexually reproducing stages, are restricted to moist habitats.

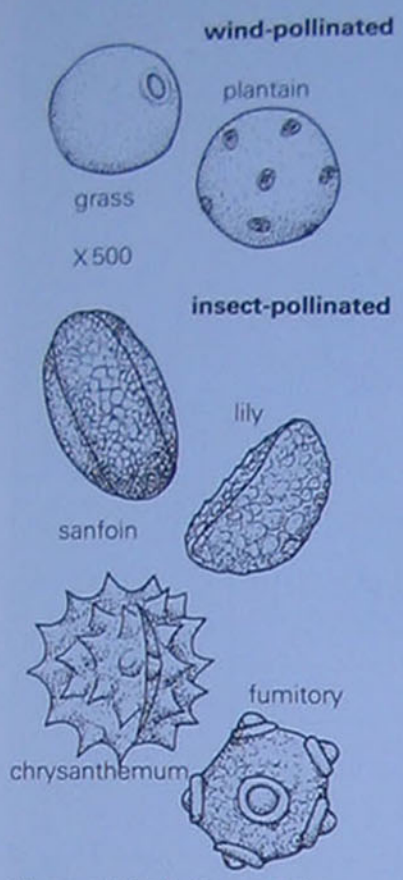
Higher plants–those that produce seeds–have a very different process of reproduction, involving pollen rather than individual gametes. Pollen does not need water to achieve fertilisation, so seed plants can live in habitats that are too dry for lower plants.

What is pollen? Pollen is a fine powder–usually yellow–produced within the anthers of a flower or, in the case of cones, within pollen sacs. This powder consists of extremely small grains, perhaps only a few thousandths of a millimetre across, called pollen grains. Each grain contains chemicals capable of manufacturing a male gamete, packaged within a special wall made from a plastic-like substance that is extremely resistant to decay.

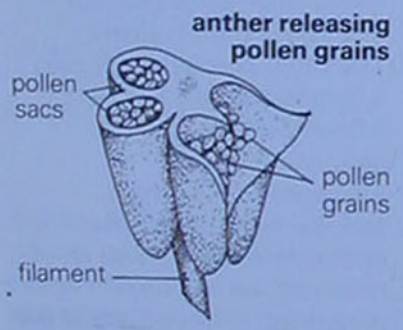
Pollen dispersal Since pollen grains are so well protected by their resilient walls, they can survive for a long time, which is a particular advantage for wind-dispersed pollen. To travel these distances, pollen grains are, depending on the species, either simply shed into the air to take their chances on the wind currents, or they exploit the feeding behaviour of animals such as insects, which move from plant to plant in search of food.

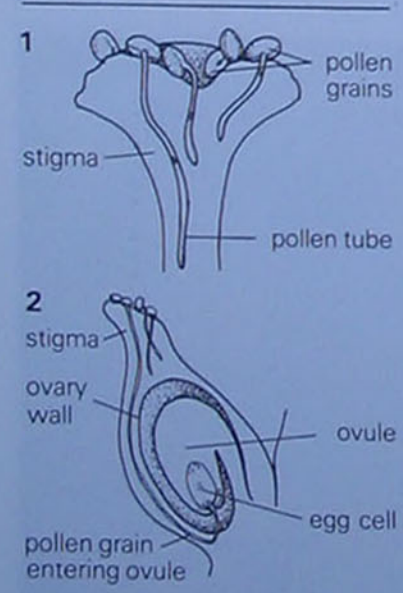
For many insects, the pollen grains themselves are the food which they gather. Although many of the grains are eaten, enough survive to be transferred to their goal–the receptive surface of the female part of another flower, the stigma. This is the process known as pollination. Pollen is much sought after as a food by insects because it is highly nutritious, containing a large proportion of proteins and carbohydrates. For the plant, however, it is an extravagant system that allows so

Pollen grain shapes



Above: Wind-dispersed pollen grains have to be small enough to remain airborne, insect-dispersed pollen grains are larger and have rougher surfaces.





Above: The pollen grains land on the stigma, sending out tubes (1) that burrow through to the ovule to initiate fertilisation (2).

much pollen to be eaten, and a drain on its resources. Many more specialised plants produce an alternative source of food for insects – nectar – which is less energy-consuming than pollen for the plant to produce. The plant then contrives to dust the insect with pollen as it searches for nectar. The same searching action by the insect allows pollen to be transferred to the stigma, effecting pollination.

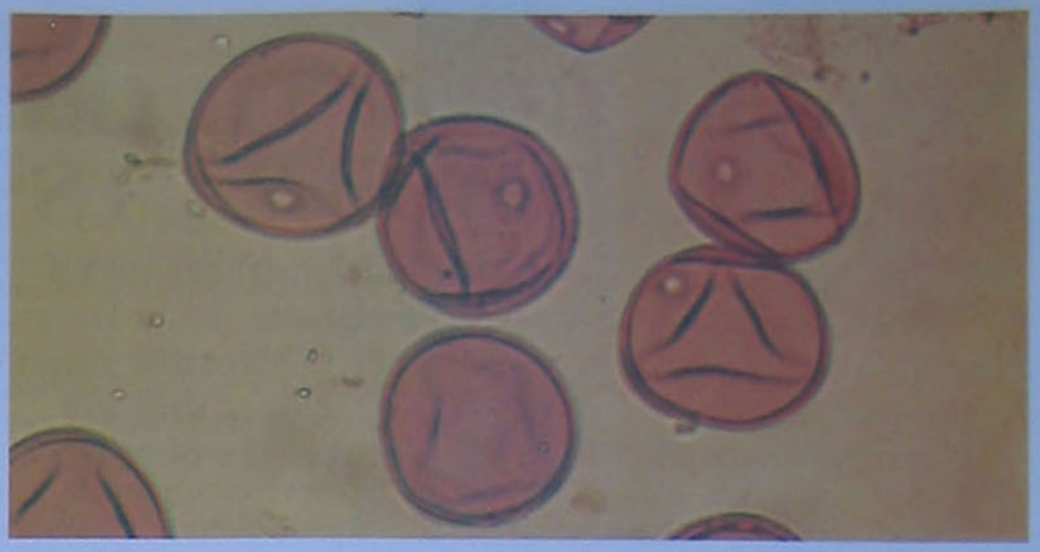
Pollination If the pollen succeeds in reaching a stigma it germinates, each grain producing one or more delicate outgrowths called pollen tubes. The tubes penetrate the tissues of the stigma and grow towards the ovaries. The energy needed for the tubes to grow is provided by the cells of the stigma, since the pollen grain itself is far too small to incorporate enough food reserves for this process. The pollen tubes eventually reach the ovary and the female sex cells inside. The male gamete is then released from the pollen grain, travels down the tube and fuses with an egg cell in a process known as fertilisation. The result is a young embryo which will develop into a seed.

In many flowering plants a pollen tube is produced only if the stigma is of the same species. (This saves the pollen tube from burrowing through to the ovary, only for the male and female sex cells to discover that they are incompatible.) This initial 'check' between pollen and stigma is achieved by an elaborate recognition process between the two parts. If the pollen grain has the correct chemical 'password' in the oily substance that coats its outer surface, it causes the stigma to release its own chemicals, which then trigger the growth of the pollen tubes.

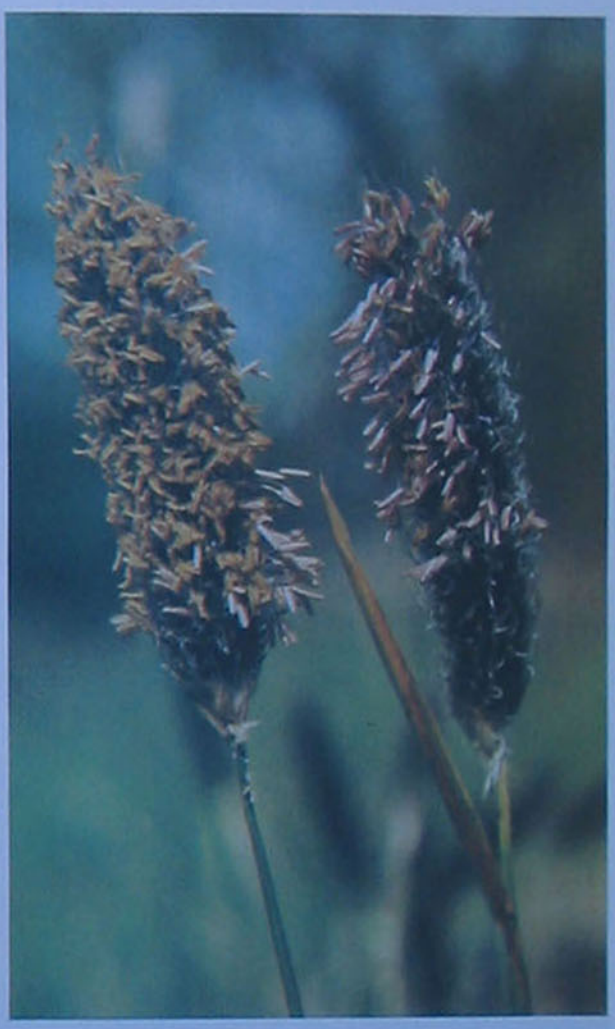
Pollen and the past So tough and resistant is the wall of pollen grains that they are often found preserved as fossils, still being recognisable even after millions of years. This means that they can be extracted and studied under a microscope, and in many cases identified because the outer walls of pollen grains often have elaborate and distinctive surface patterns or shapes.

Such investigations allow a picture to be built up of the species of plants present in the vegetation at any particular time in the past. This tells researchers a great deal about our past climate. For instance, the presence of a high proportion of conifers indicates a cold climate. Furthermore, it is also possible to estimate which were the abundant species in the ancient vegetation and which were not.

Thus the pollen grains provide one of the best ways of studying past vegetation. In Europe, the vegetational history from before the Ice Ages to the present time is now well known as a result of this type of botanical detective work. The accuracy of the pollen record is such that the influence of mankind on the British flora is clearly shown from the early forest clearances to the introduction of some of the weeds associated with modern agriculture.



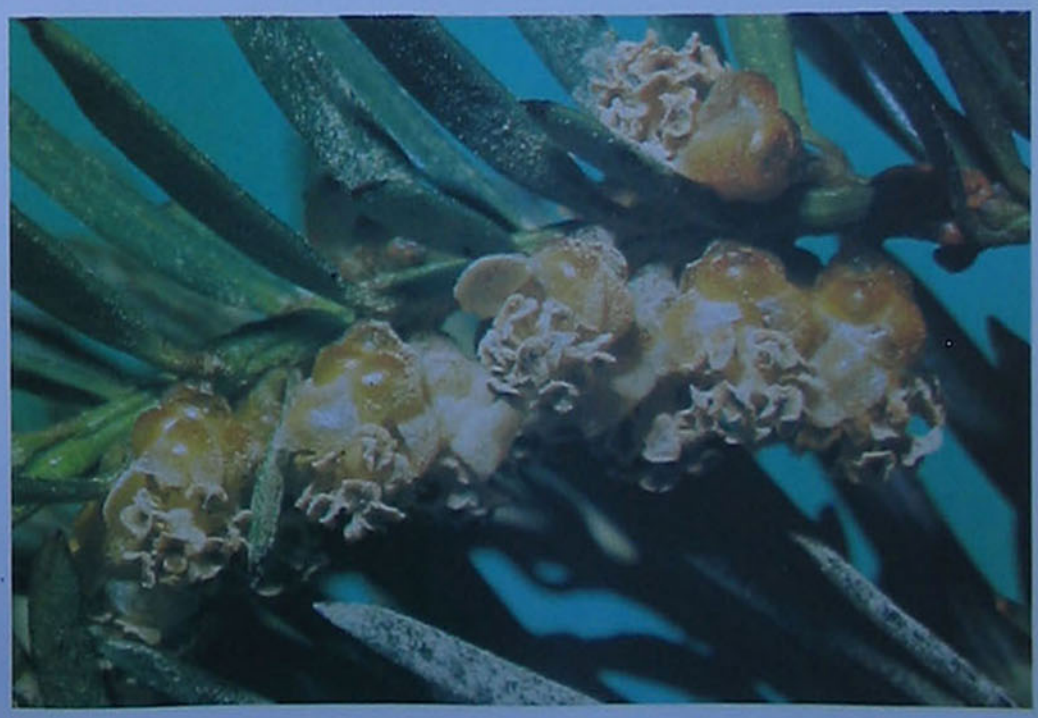
Above: Pollen grains of timothy grass (*Phleum pratense*) photographed through a microscope. The white spots are pores through which the pollen tube grows after pollination. The dark lines are where the walls of the grains have folded while the sample was being prepared for the microscope. The process has also caused the artificial orange colour of the grains; in real life they are a very pale yellow.



Right: Timothy grass at anthesis, the process in which the anthers split open (usually lengthwise) to release the ripe pollen.

Opposite page: A hive bee dusted with pollen from the flower of musk mallow.

Below: Many conifers produce copious amounts of pollen, particularly the yew, the ripe male flowers of which are shown here.



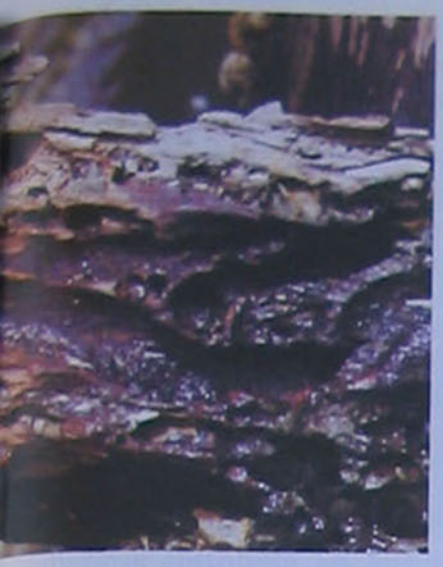
MARINE GROWTH ON MAN-MADE OBJECTS

In the open sea environment, hard surfaces on to which sessile organisms can settle are in short supply. Man-made structures–piers, platforms, ships, buoys and so on–provide extra surfaces that are often colonized by 'fouling' plants and animals.

The tenacity with which sessile organisms attach themselves to hard objects creates problems for man. Ships require special cleaning to remove marine growth–especially barnacles and tubeworms–and only the fastest vessels are able to dislodge these animals, while slow cargo ships may accumulate several hundred tons of 'fouling' on their hulls. Power stations, too, which use sea water to cool condensers, fight a continuous battle against fouling organisms, particularly the common mussel. Mussel larvae are drawn into the sea water pipes and attach themselves firmly to the inner walls. Their growth is usually rapid because large quantities of nutrient-rich water is continually drawn past them. The pipes can be completely blocked by mussels in a relatively short time. Navigation buoys are often so extensively fouled that it is necessary to remove and clean them annually. Oil and gas platforms in the North Sea are fixed permanently to the sea-bed and new techniques have had to be developed to remove the marine growth on them, while man-made structures (such as piers) situated close to the coast are often covered rapidly by a fouling community of seaweeds, barnacles, mussels, tubeworms and hydroids.

In order to understand the reasons for the differences in fouling rates and species diversity, it is necessary to consider the behaviour of the spores and larvae–called the propagules–of fouling organisms. Sessile marine organisms, like plants on land, rely on propagules to establish new colonies. Many common rocky shore organisms produce enormous numbers of propagules during the summer months. Those of some species are floating (pelagic) forms and are carried by currents far away from their parents. Other organisms produce non-swimming propagules which either sink rapidly to the sea-bed or are able to crawl about for a short period of time in search of a suitable substrate on which to live. Non-swimming reproductive bodies are usually not carried far from their parents.

Common fouling organisms The common mussel is one of the most widespread fouling organisms around the British Isles, being found on such inshore structures as piers and



Above: Ship's timbers riddled with holes made by the wood-boring shipworm.

Opposite left: The common mussel is often found fouling man-made structures. This has been put to good use in mussel culture for commercial purposes.

Top right: Plumose anemones—solitary fouling animals.

Right: Pier supports exposed at low tide reveal a number of clinging sea squirts and sponges.

navigation buoys and also on oil and gas platforms over 200km (125 miles) from the coast. It is estimated that a large mature female mussel produces, on average, 25 million eggs during the summer spawning season. The larvae are pelagic and drift in the sea for at least three or four weeks. After this they are sufficiently mature to settle.

Obelia dichotoma, a small hydroid, is another widely distributed fouling organism present on inshore and offshore structures. Minute jellyfish are produced by the sessile colonial stage of its life-cycle; they feed in the plankton for several weeks, then reproduce sexually. The fertilised eggs rapidly develop into larvae which settle and grow into sessile colonies within a few days.

Another common hydroid found on a great diversity of man-made structures is the hydroid *Tubularia larynx*. It is among the first species to colonize wrecks, newly installed North Sea platforms and buoys. Unlike mussels and *Obelia*, this species does not have a pelagic stage. The larvae sink slowly through the water and crawl about on the substrate. It is therefore something of a mystery how this animal colonizes structures many kilometres out to sea, structures on the sea-bed and even floating objects. However, this hydroid is probably present on many reefs and rocks on the sea-bed around Britain and ships sunk close to these hard surfaces are in range of the crawling larvae. The same

is also probably true for oil platforms, but yet another means of infestation is possible. Many records exist of hydroid colonies attached to flotsam and even to living marine animals. Such substrates are probably responsible for transporting sessile animals great distances and flotsam carried out to sea after a storm may become entangled in the steel bracings of platforms and anchor chains of buoys. Mature colonies of *Tubularia* attached to the flotsam can release their young in close proximity to a hard substrate and an initial settlement of only a few larvae can soon give rise to an extensive colony.

Seaweeds and sunlight Several common rocky shore organisms appear only on man-

Fouling results

The smothering growth of colonial animals may have an adverse effect on man-made structures by increasing the density and thickness of the fouling community. For example, ships use more fuel since their speed is reduced by the increased friction on the hull. On platforms, steel bracings in the shallow regions are subjected to greater wave loading and may crack along welds. Smothered organisms decay and an anaerobic (oxygen-lacking) micro-environment may become established where the steel/fouling community meet. Sulphate-reducing bacteria become active in anaerobic conditions and the activity of these micro-organisms appears to speed up corrosion processes. Modern anti-fouling methods can alleviate fouling problems but cannot prevent them.

Above: Hydroids growing on a mussel. Most sessile solitary animals have a hard, mineralised exoskeleton or shell and as growth continues it becomes more and more difficult to prevent other organisms, especially colonial animals, settling on and smothering them. Colonial animals are less likely to become overgrown by other colonial species, or even solitary species, because they possess a variety of defences. Hydroids have tentacles which bear stinging cells and bryozoans often have oral spines or specialised zooids called avicularia, all of which help to keep colonies free of settling larvae. Some species even have poisons which kill competitors for space.

The Fair Isle Current

An enormous number of mussel larvae are carried into the North Sea by the Fair Isle Current, an offshoot of the North Atlantic Drift. This current flows through oil and gas fields, where many of the mussel larvae settle on the production platforms. Before North Sea oil they would have perished.

made structures close to the shore. The common brown seaweeds called wracks are found on piers and wharfs but rarely on more distant structures. The propagules of wracks are large and heavy and sink rapidly. Those sinking into deep water cannot survive because seaweeds require sunlight to convert the nutrients they absorb from the surrounding sea water into organic matter. Only propagules falling on to hard substrates in sunlit water have a chance of survival.

Some seaweeds have buoyant spores which are capable of colonizing structures many kilometres out to sea, but again only those settling on sunlit surfaces survive. The green sea lettuce and the red seaweeds are often common on gas and oil platforms around Britain. However, their distribution is restricted to the splash zone down to a depth of about 12m (40ft). Even within this depth range they colonize only sunlit surfaces.

Sunlight also plays an important role in the settling behaviour of the larvae of many sessile animals. Pelagic larvae are attracted to light during early larval life, this behaviour helping to disperse the larvae by ensuring they live close to the surface of the sea. Some species continue to be positively attracted to light up until the time of settlement, thus confining settlement to shallow water. On the seashore this behaviour helps to minimise predation pressures. For example, mussels settling below tide-marks are usually eaten by their arch-enemy the common starfish, but those living between tide-marks can only be attacked during high water. Even on man-made structures mussels continue to be confined to low water areas.

The pelagic larvae of other species often actively seek dark environments. If this response takes place close to the time of settlement, then the larvae will be most abundant

Left: Goose barnacles on a large plank. The plants and animals that make up a fouling community are mostly attached, or sessile, forms which occur between tide marks along rocky shores or on hard objects on the sea-bed. A list of species found on piers, ships, buoys, and oil and gas platforms in the waters around the British Isles shows that these fouling organisms are drawn from members of natural populations. The goose barnacles are, perhaps, slightly unusual in being found more in open waters than close inshore. They are renowned for infesting the bottoms of boats and pieces of driftwood.

Hydroid
(Obelia dichotoma)

Deep-water barnacle
(Balanus hameri)

Common mussel
(Mytilus edulis)

Seaweed
(Polysiphonia)

Strong attachments
Sessile organisms adhere firmly to the surface on which they settle and have evolved several methods of adhesion to combat strong wave action and currents. Hydroids send out branching tubes which adhere to cracks and crannies, while other animals, such as barnacles, have developed strong 'cement' to hold them to the substrate. The common mussel attaches itself by secreting a mass of root-like 'byssus' threads and seaweeds rely on holdfasts.

Left: *Balanus hameri*, the deep-water barnacle, is a good example of an animal whose pelagic larvae seek out dark environments. The sessile adult is found on hard objects in deep water – such as the fishing float (recovered from the sea-bed) shown here. The early larval stages are pelagic, but the final larval stage sinks into deep water in search of a suitable hard surface on which to settle for adult life.

Below: *Filograna implexa*, an aggregate tubeworm, is a solitary fouling organism that is unusual in being able to reproduce asexually. It produces enormous numbers of offspring which together construct dome-shaped 'colonies' 30-40cm (12-16in) high.

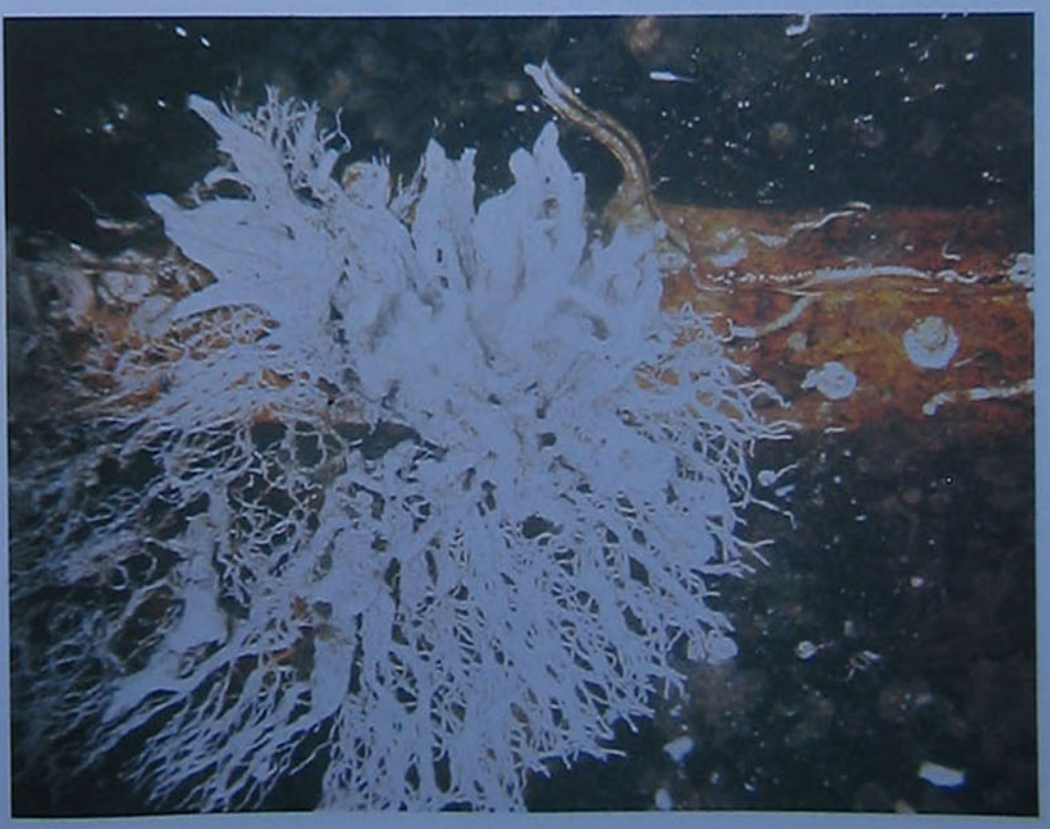
under rocks and in crevices between tide-marks. On man-made structures this can result in heavy, troublesome fouling of inlet pipes, sonar equipment and anchor attachment points. Several species of barnacle and tubeworm exhibit this type of behaviour.

Gregarious settlement A powerful settling stimulus for some larvae is tactile contact with adults of their own species. The larvae of the keel-worm *Pomatoceros triqueter* settle readily on surfaces already colonized by adult keel-worms, while the final larval stage of barnacles settle in close proximity to either living or dead adults. In the case of barnacles it is important that they do settle close to each other because, prior to reproduction, cross-fertilisation takes place.

For solitary sessile organisms, gregarious behaviour may also serve as a defence mechanism. Because competition for living space is severe, sessile solitary organisms, which may be the first to settle on new hard substrates, soon become smothered and killed by sessile colonial species unless they have some means of defence. When tubeworms and barnacles settle in dense aggregations their growth form is altered. Tubeworms grow at 90° to the surface instead of prostrate, while barnacles become greatly elongated and columnar in form. These aggregations therefore present an outer 'colony' surface consisting of a mass of feeding structures. The feeding activities of the 'colony' then reduce the probability of colonial animals smothering them.

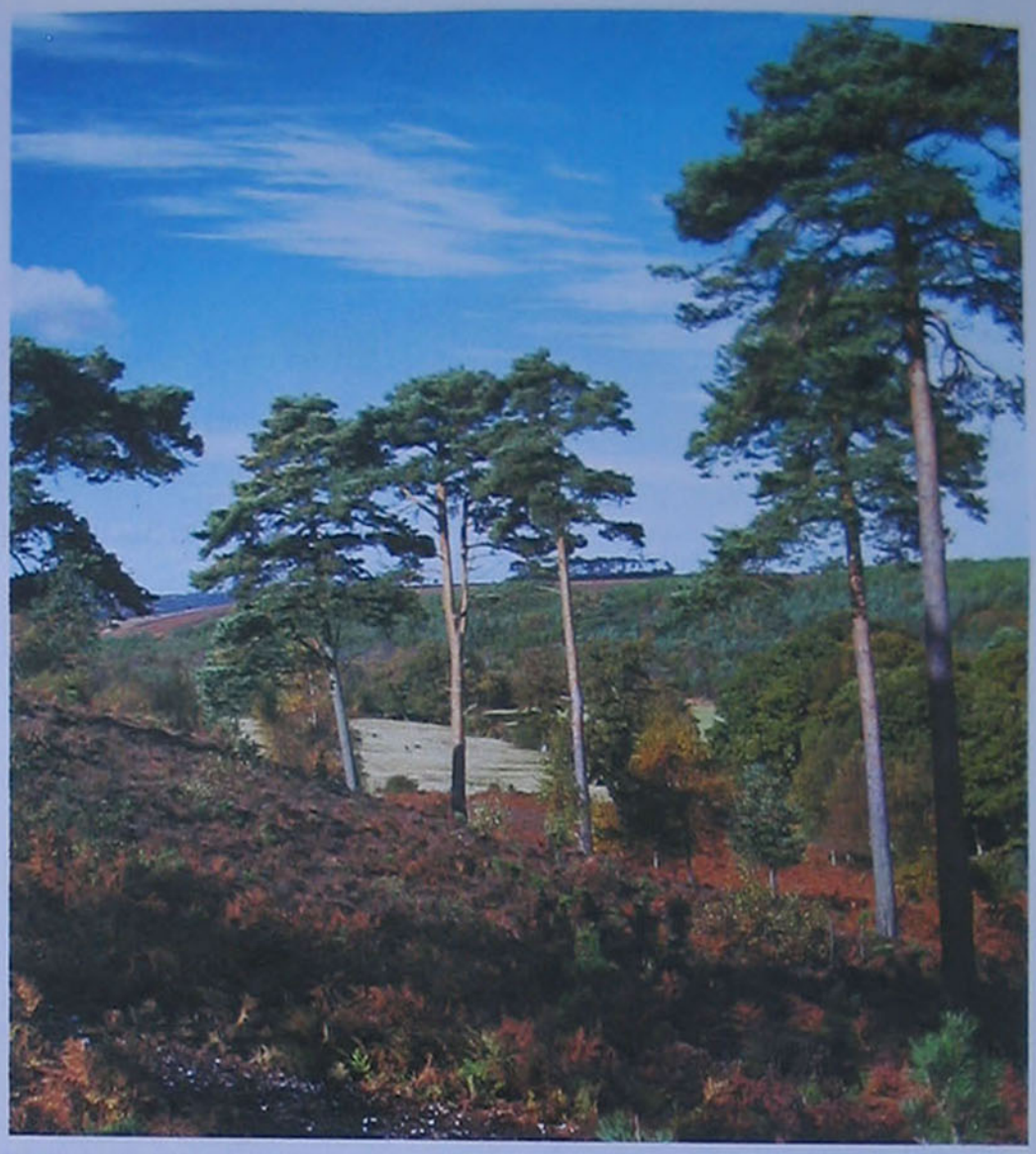
Most solitary fouling organisms, however, can only reproduce sexually, and the re-aggregation of their pelagic larvae on man-made structures long distances offshore is difficult to achieve. However, two solitary fouling species are able to reproduce asexually: these are the aggregate tubeworm *Filograna implexa* and the plumose anemone *Metridium senile*. The offspring of *Filograna* together construct dome-shaped 'colonies', while the offspring of *Metridium* stay in close proximity to their parent, those on the periphery of the family group being equipped with special stinging cells to ward off other anemones trying to encroach on their territory.

Colonial animals are much better adapted to a sessile existence than solitary ones. All can reproduce by asexual as well as sexual means, and they are also less susceptible to being overgrown by other colonial species. The growth of colonial fouling organisms can, therefore, be completely smothering.



A LOOK AT THE PINE FAMILY

To the unpractised eye, firs, spruces and the other members of the pine family look much like one another–until you know what clues to look for.



Above: Most conifers have a uniform conical shape but some pines tend to a more irregular growth habit–the Scots pine, for instance, develops a long unbranched bole supporting a broad, flat-topped crown.

Below: Like all pines, the Scots pine has stiff, needle-shaped leaves borne in small bundles, in this case pairs.

Many budding naturalists find it much more difficult to identify the various species of conifer trees than the broad-leaved trees. They soon learn to tell, for instance, an oak from an ash because the leaves and fruits are all markedly different. But conifers, with their needle-like leaves and cones, can all seem to be much the same. Yet, after a little practice, telling a spruce from a pine becomes just as easy as telling an oak from an ash.

Most conifers seen in Britain belong to one large family, the pine family or Pinaceae. This is the largest of the conifer families, with about 200 species spread through the Northern Hemisphere. Members of the pine family can usually be easily distinguished from other conifers by their oblong, linear or needle-like leaves and their cones, whose woody or leathery flat scales carry pairs of seeds, usually winged.

The other conifer families differ in various ways. They may have awl-shaped leaves, as do some members of the swamp cypress family; or, if the leaves are oblong and more typically pine-like, then the cones develop either into fleshy cups bearing seeds (as in the yew family) or into plum-like bodies (as in the yellowwood and plum yew families). The maidenhair tree of the ginkgo family has distinctive fan-shaped leaves, and the Chile pine family–which is quite different from the pine family–is an unmistakable group from its only common British species, the monkey puzzle tree with its 'spiny' foliage. The remaining family of conifers is the cypress family, which is characterised by its small scale-like leaves that clasp the stem in opposite pairs.

Into the pine family Deciding whether or not a particular tree is a member of the pine family is fairly straightforward. But, having established that the tree does belong in the pine family, deciding which genus it belongs to can be more difficult at first.

There are ten genera in the pine family, of which three are very rare in Britain. The remaining seven occur in parks, gardens and forestry schemes and can almost always be distinguished by their twigs and foliage, though you must beware of species whose features place them at the boundaries of the groups.

The pines This genus (*Pinus*) is the largest in the family with almost a hundred species, although only about a dozen are at all common in this country. Members of the genus *Pinus* are uniquely characterised by their foliage–their needle-like leaves are borne in bundles of either two, three or five. The leaves that are borne in twos are semi-circular in cross-section, and those borne in threes or fives are roughly triangular. The mature cones are woody and vary in length from 3cm (1¼in) to 40cm (16in), depending on

the species.

The spruces There are about 40 species of spruce (*Picea*), of which some 15 are found in Britain. Their leaves differ from those of pines in being stiffer, sharp-pointed and flattened. They are borne singly on the shoots and are carried on small woody pegs, which remain attached to the twig when the leaves fall. Spruce cones are less woody when compared with those of pines and have a more cylindrical shape.

The silver firs Many species in the genus *Abies* can be recognised at a distance by their even, conical shape with regular circles of branches. Of the 50 species in existence, about half are cultivated in Britain. The leaves are firm and leathery, and more or less evenly spread on each side of the shoots. Only rarely do they have a tip as sharp as spruce leaves. The bases of the leaves are circular and, when the leaves fall, the twig remains marked with a distinct flattish pale scar. The mature cones vary in length from 5cm (2in) to 25cm (10in) and are borne erect on the tree. They are frequently encrusted with dried resin and when they shed their seeds they break up on the tree, leaving behind candle-like cores. On other conifers the cone scales open to release the seeds, but otherwise the cones stay intact.

The larches Of the ten species of larch (*Larix*) found in the wild, only three are anything but rare in this country and one of these is a hybrid. All larches have pale green, linear leaves, and they are all deciduous – the only members of the pine family to be so, apart from one minor genus, the golden larches, species of which are rare in Britain.

Above: The erect barrel-shaped cones are a unique and unmistakable feature of cedars – in this picture a cedar of Lebanon. Cedars and larches are the only two genera in the family to bear their leaves in tufts (except on the young shoots, where the leaves are borne singly). All other genera bear their leaves in bundles (pines) or singly.

Below: The leaf arrangement of cedars and larches can be seen more clearly in this picture of a larch in autumn. Note how the leaves are dying and about to fall.

Another distinguishing feature of larches is that their leaves are borne in tufts or whorls, except on new growth where they are borne singly. The young male cones are inconspicuous and reddish; young female cones are also reddish but mature to become brown and up to 4.5cm (1¾in) long.

The cedars Of the four species of cedar (*Cedrus*), three are common in large gardens and parks in Britain. Fully grown, they are all massive trees, similar in outline to the familiar cedar of Lebanon. The leaves are flattened somewhat and needle-like, often with translucent tips. They have the same manner of growth as larches: the leaves are borne singly on the young shoots and in tufts further back. Only these two groups have this arrangement, and the cedars are easily distinguished from the larches by their evergreen leaves.

The mature female cones are large (up to 8cm/3in long) and distinctively barrel-shaped. Like those of the silver fir, the cones are borne erect on the branches.

The Douglas firs Only one species of this genus (*Pseudotsuga*), the Douglas fir itself, is at all frequent in Britain, though two or three others are cultivated here. The leaves of this group have a soft texture and lack a sharp tip. They are narrower than the leaves of spruces or silver firs and they are borne on the shoots in two more clearly defined lateral ranks. The leaves arise from raised angular bases which, after the leaves have fallen, give the bare twig a rough feel. The mature cones have long three-pointed bracts which extend beyond the cone scales. The terminal buds on the stems are also characteristic, being spindle-shaped, reddish-brown and smooth.

The hemlocks Three species (*Tsuga*) are common in Britain. They are all smaller trees than the rest of the pine family. Their leaves are densely set on the shoots, but they are less regularly arranged than on other species. The mature cones are very small – less than 3cm (1in) long – except for one species, the mountain hemlock, which has cones up to 7cm (2½in) long.

The Pine Family

Cedar *(Cedrus)*

Spruce *(Picea)*

Silver fir *(Abies)*

Larch *(Larix)*

Hemlock *(Tsuga)*

Douglas fir *(Pseudotsuga)*

Pine *(Pinus)*

Leaves borne in tufts on older shoots, singly on young shoots. Barrel-shaped, erect cones distintegrating on the tree. Characteristic broad outline with branches in layers.

Stiff, sharp-tipped needles borne singly on the shoots and attached to them via woody pegs. Cones hang down from the shoots.

Regular, conical outline. Needles leave a flat pale scar on the shoot when they fall. Cones borne erect.

Pale green, deciduous needles borne in tufts on older shoots, and singly on young shoots. Cones are small and may remain on the tree for many years.

Small trees. Leaves borne singly along the shoots and less regularly set along them than on other genera. Except for one species, the mature cones are very small—smaller than larch cones.

Soft-textured needles borne on two clearly defined ranks on the shoots. Needles arise from raised angular bases. Cones have long bracts which terminate in three sharp points.

The only genus to have its needles borne in bundles of 2, 3 or 5. Some have a long unbranched bole topped by a broad spreading crown.

FOOTMAN AND ERMINE MOTHS

Footman moths, so named because their elongated stance resembles that of a footman in livery, and ermine moths – which derive their name from their similarity to ermine – belong to the same family as the notoriously poisonous tiger moths.

Most of the 15 species of footman moths (members of the Arctiidae family) found in the British Isles are small, delicate creatures with narrow forewings spanning about 3.5cm (1¼in), and broad hindwings which fold up like a fan when the moth is at rest. Over half our species are fairly rare or local; the following six, however, are common in southern England but not all of them extend as far as Scotland.

Standing to attention The common footman is, as its name implies, widespread in England, and it also occurs in Scotland and Ireland. In the daytime it rests among the vegetation – its stiff footman-like stance giving a clue to its identity. If shaken out of the vegetation it falls to the ground where it lies completely still.

The adults, which fly around after midsummer, are distinguishable by their pale lead-grey forewings, which are lined with a yellow streak along the front edge that tapers out just before reaching the wing-tip, and their pale yellow hindwings.

The rather unsuitably named scarce footman is by no means rare, although it is confined to the south of Britain and Ireland. Its wing coloration – pale grey forewings with a yellow streak extending right to the tips, and yellow hindwings – is remarkably similar to that of the common footman, but when at rest it is wholly distinct, as it wraps its wings around its body instead of laying them flat like the common footman.

Two varieties of dingy footman In its shape and resting posture, the dingy footman is similar to the common footman. Its wings, however, are slightly broader, and there is only a faint suffusion of yellow along the front margin.

Apart from the normal pale grey form of dingy footman, there is a variety which has entirely pale yellow forewings. Curiously, this yellow form – which was once regarded as a separate species – is confined to Britain, even though the usual form of the moth is common throughout Europe.

The dingy footman is found in southern England and Wales, but the endemic yellow form is rather sporadic in its occurrence and no definite pattern of distribution has yet been established.

Relaxed posture The four-dotted footman has fairly broad forewings, so that unlike the other resting footman moths it does not appear to be 'standing to attention'. There are two dots on each forewing, and the wings are typically greyish-white with a faint yellow border, although again there is a variety with orange-yellow forewings. The distribution of the four-dotted footman extends to Scotland but not Ireland, the orange-yellow variety being most prevalent in south-east England.

By far the prettiest member of the footman moths is the rosy footman, which has wings spanning a mere 2.5cm (1in). This species, which also lacks the typical 'footman' appear-

Above: The common footman moth (*Eilema lurideola*) may be found resting by day among foliage.

Left: The four-dotted footman (*Cybosia mesomella*) has two dots on each forewing.

Previous page: The spectacular white ermine moth (*Spilosoma lubricipeda*).

Below: You can find the rosy footman (*Miltochrista miniata*) in woodland in southern England.

ance when at rest, has rounded pink forewings which are brighter around the margins, with delicate scribble-like markings. It is a woodland moth and is commonly found in southern England.

The least footman-like of all the common species is the muslin footman, a small moth with a wingspan of about 2cm ($\frac{3}{4}$in). Its wings are pale grey and semi-transparent with faint darker grey lines and spots. It occurs all over Britain except northern Scotland.

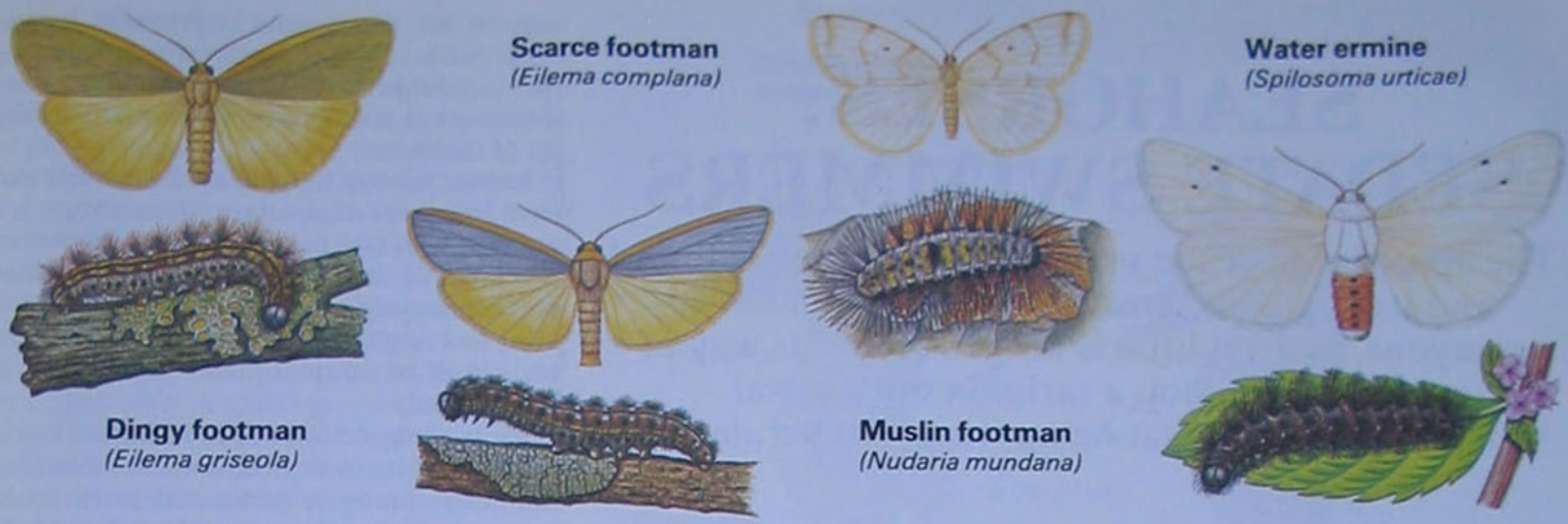
Rare footman moths Two other species deserve a brief mention: the buff footman (*Eilema deplana*) which has ochre-grey wings with a faint yellowish tinge along the front edge, and is local in southern England; and the red-necked footman (*Atolmis rubricollis*), a distinct species with velvety-black wings, a red patch on the front of the thorax, and a yellow one at the tail end of its body. It occurs sporadically in southern England and Wales in wooded country.

Woolly bear caterpillars The caterpillars of footman moths are all hairy, and very similar in their habits. They all feed on lichens or algae, although some species may accept fresh or decaying leaves if kept in captivity. Most footman moth caterpillars live on the trunks or branches of trees, usually without much preference for the kind of tree, but a few, such as the muslin footman, live as caterpillars on rocks and stone walls.

All footman moths have a single generation a year, with the larval stage extending over a long period – usually from about August of one year until the following May or June.

Magnificent ermine moths Three species of ermine moth – also members of the Arctiidae – occur in Britain; two (the white ermine and the buff ermine) are extremely common, while the third (the water ermine) is local and rather rare. All three species have a wingspan of about 4cm ($1\frac{1}{2}$in) and are either white or yellowish-white in colour.

The caterpillars of ermine moths are densely hairy woolly bears and feed on a variety of plants with leaves near the ground, such as dandelions and plantains. There is one generation a year and they overwinter as pupae.



Above: Four footman and ermine moths and their caterpillars. All the caterpillars are hairy and feed on lichens or algae growing on trees.

Right: The buff ermine moth (*Spilosoma lutea*) can vary considerably in appearance – some specimens are buff-coloured with black striations (right), while others are cream with dark dots (below). The difference can be so great that at one time the two varieties were thought to be completely different species. Tests have revealed that, despite its apparent warning coloration, this moth is palatable to birds, which suggests that it may gain protection from mimicking the distasteful white ermine moth.

The white ermine moth is our most abundant arctiid moth and is found all over the British Isles except in the Shetlands. Typically it is creamy-white and heavily spotted with black; the abdomen is yellow with black markings. The spotting on the wing varies from sparse to dense and occasionally the spots may be joined to form streaks. The ground colour also varies. In Ireland most specimens have an ochreous tinge and some of the males are yellowish-brown – similar specimens have also been recorded in Scotland.

The larva, which is covered with blackish hairs for protection, leaves its foodplant when fully grown and crawls about rapidly before settling down to spin its cocoon and pupate. It is one of the few caterpillars that can be said to run – this struck the great 18th century Swedish naturalist, Linnaeus, so forcibly that he gave the species the name *lubricipeda* meaning 'slippery foot'.

Buff ermine The male buff ermine is yellowish-buff with dark spots, some of which usually form an irregular streak running back from the tip of the forewing. The female has a much paler ground colour, often creamy-white, so that it looks similar to the white ermine moth. Again the density of the spotting is variable.

Since the buff ermine moth is palatable to birds and looks similar to the distasteful white ermine, scientists believe that it might mimic the latter for protection. If this is so, the mimicry is more likely to be effective in protecting the female buff ermine as her resemblance to the model (the white ermine) is closer than that of the male. The buff ermine moth caterpillars are similar to those of the white ermine moths, but brown rather than blackish in colour.

Rare water ermine If you come across an ermine moth that is pure white it is likely to be the water ermine. The black dots on this species are fewer and smaller than on the other species and may be limited to one or two dots near the middle of the forewing, or even no marks at all. It is found locally in south-east England, always in fens and marshes, where its hairy brown caterpillars feed on low plants growing near the water.

SEAHORSES: SEDATE SWIMMERS

The appearance of the seahorse, with its angled head and its mane-like crest of spines, is familiar to everyone, and yet little is known about its way of life. It is, in fact, a rarity in our coastal waters, its main habitat being warm temperate seas.

Below: Three mature seahorses, two with their tails wrapped round plant stems. You can see numerous young seahorses (tiny versions of the adults) nearer the surface. Bearing an extraordinary resemblance to a horse in miniature, seahorses have captured the imagination of artists and designers, and are generally well known to the public. Their hidden life-style, however, makes detailed observation difficult.

Seahorses are fishes: together with the pipefishes they make up one of the few families of fishes in our waters that have an 'armoured' casing. The series of bony rings along the body looks almost like the shell of a crustacean. Within this group, the seahorses are unique in European waters for their upright swimming posture as well as for their body shape: the tail is capable of curling forwards, and the head is set at an angle to the body.

Although externally the seahorse looks different from any other fish, inside the body there is a perfectly normal fish skeleton, with vertebrae running from head to tail tip, except that the bones are slender in comparison with those of most fishes. Most of the support for the muscles is provided by the armour-like casing. A feature which seahorses and pipefishes share is the tube-like snout; the mouth is small and is located at the very tip of the snout.

Inshore habitat Judging by the records that have been kept of sightings, the seahorse is a rare fish in British and Irish waters. However, it is possible that this fish is commoner than the records suggest, for it is small, growing at most to 15cm (6in) in total length, and conceals itself by adopting the coloration of its background.

In its normal habitat the seahorse lives in inshore waters in depths down to 4-5m (2-2½ fathoms) among eel-grass and green-brown seaweeds. Seahorses are nearly stationary for much of the time, holding on to plant stems with their prehensile tails. Even when moving around in search of food, they do not move quickly–and they rarely swim if the water is not very still. They swim in a slow, sedate, upright manner–well suited to avoiding detection. Occasionally a sudden wave movement, perhaps in a storm, dislodges them from the plant stems, and then they are swept away. It is after events of this kind that seahorses are found dead on the seashore, but if they are swept out to sea they may drift for many miles outside their normal habitat.

Seahorses occur mostly on the southern and south-western coasts of Britain, from Sussex west to the Scillies, then up the western

coasts, decreasing in numbers the further north one goes. On the Irish coast, most records are from the south and west coasts. This distribution reflects the southerly origins of our seahorses, which are commoner in the Mediterranean and on the Atlantic coasts of France, Spain, Portugal and Morocco; from here, it is thought, they are carried by surface currents northwards to the British Isles.

Subtle predator The tube-like snout limits the size of food on which seahorses and pipefishes can live, but it is well adapted to the food they take. A seahorse moves slowly, so as not to attract attention, snapping at small passing animals such as crustaceans and the larvae of other marine animals, which are found in the relatively still water among the marine vegetation. It is able to turn each eye in a different direction, so commanding an unusually wide angle of vision. Having located a suitable prey, the seahorse leans forward to seize it.

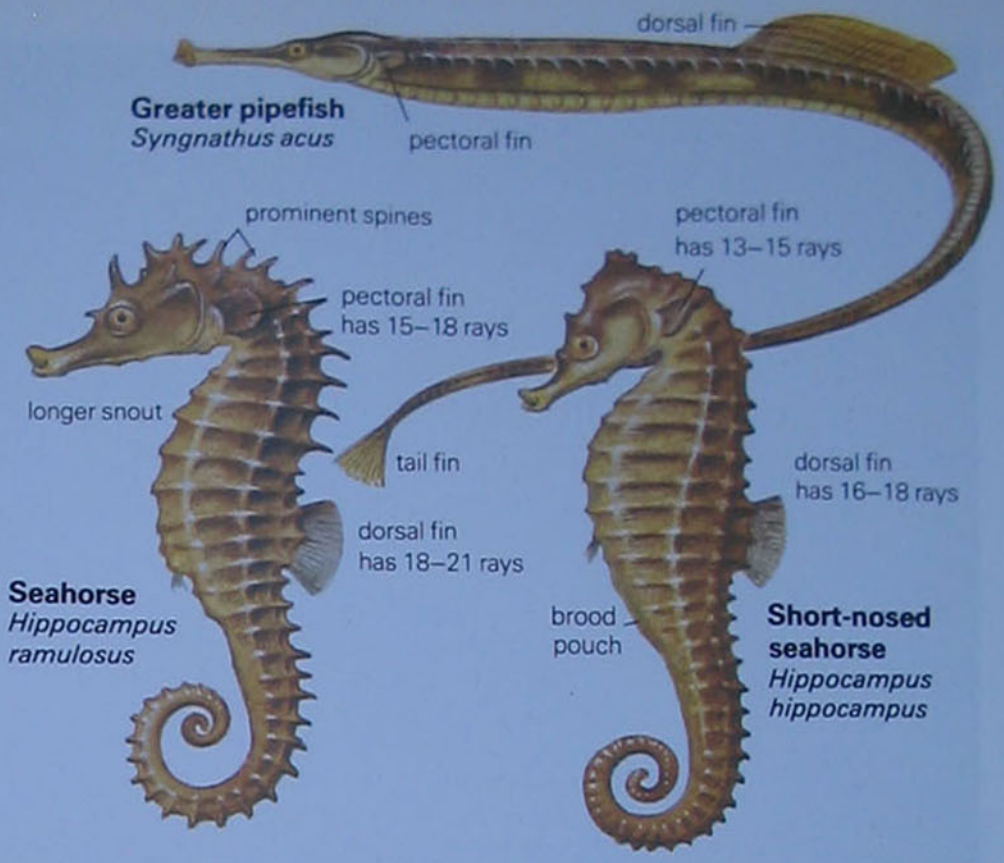
Unusual breeding The female seahorse produces the eggs and the male's sperm fertilises them, but they are the sole charge of the male once they are fertilised. Seahorses and pipefishes have fascinating incubating and brooding habits which are almost unique among fishes. In pipefishes, the details vary with the species: some simply have a shallow groove along the belly in which the eggs are lodged, while others have flaps of skin on the tail inside which the eggs develop. But the seahorses have developed the system to an advanced degree. The extraordinary process has the unlikely appearance of a male fish giving birth to young.

The male has a pouch at the base of his tail attached to the abdominal region. The pouch has a small pore-like opening which, during the breeding season, is relaxed and open. The female lays her eggs directly on to this pore, and the eggs develop within the pouch. Up to 200 eggs or young fishes may be present in the pouch of a large adult male. When they are well developed they are expelled in a series of muscular spasms which convulse the whole body of the seahorse.

Breeding occurs in summer, and males with developing eggs have been found in all the summer months, from May to August.

The emerging young When expelled from the pouch, the young are recognisable as tiny seahorses. They swim in the upright manner of their parents, but they are thin and fragile. They are, like their parents, extremely feeble swimmers. It is thought that they spend a short time in the vicinity of the adult male, though they do not re-enter the pouch. When bred in aquaria, young seahorses are often quickly eaten by adults, so in the wild they may naturally disperse, thus avoiding this fate.

It is probable that at this time many young seahorses are swept away by tidal movements into the open sea and then, depending on prevailing currents, are carried northwards into British waters and along our coasts.



Above: Three members of the remarkable pipefish family of 'armoured' fishes. The illustration also shows the difference between a male seahorse with young in its brood pouch (right) and one without (left).

Below: The seahorse swims at a gentle pace in an upright posture. The main means of propulsion is the dorsal fin, but even this is too small for fast swimming. The pectoral fins are still smaller, and are set close behind the head.

Two species The few British seahorses that have been available for examination have all proved to be the widespread southern European species, *Hippocampus ramulosus*. However, a few years ago a specimen of a second species was found on the coast of Guernsey. This was *Hippocampus hippocampus*, also widespread in southern Europe, and distinguished by having a shorter snout. Since then there have been no other records of the short-nosed seahorse. Even so, this single occurrence shows that all seahorses have to be examined very carefully to find out which species they represent. We may have a small population of short-nosed seahorses.

SQUARE STEMMED FIGWORTS

Closely related to foxgloves and snapdragons, our tall upright figworts have small, delicately structured flowers and unusual square stems.

Figworts belong to the genus of plants, *Scrophularia*, in the family Scrophulariaceae. The figwort family, as it is sometimes known, is familiar to most people from two popular members, the garden antirrhinum or snapdragon, and the foxglove.

About 300 species of figwort are found over the temperate areas of the Northern Hemisphere and five of them grow in the British Isles. Of these, four are native, while the other is a Continental species which has escaped from gardens and become locally naturalised.

The English name for these plants was given to them because they were thought to cure haemorrhoids, which, in Latin, is known as 'ficus'–this word also means 'fig' in Latin, hence figwort. Their botanical name, *Scrophularia*, may also have a medicinal origin because figworts were once widely used to treat scrofula, a form of tuberculosis. Alternatively, the name could come from the custom of country people using the leaves to cure their pigs of scab–the Latin for pig is 'scrofa'.

Square stems All British figworts are tall, erect perennial herbs with characteristic square stems and leaves borne in opposite pairs. Unlike many other members of the family, which have showy flowers to attract pollinating insects, British figworts have small, insignificant flowers coloured a dingy shade of purple, green or greenish-yellow. Each flower has five small lobes, arranged as a pair of lips on the top of an almost spherical tube. Inside the tube are four fertile stamens, and on some species, including our four native ones, there is a fifth stamen which lacks an anther and has been reduced to a sterile structure called a staminode. The staminode often provides a useful means of identifying a species.

To us, the flower of a figwort, in particular the knotted figwort, has a most unpleasant smell, but it attracts a range of pollinating wasps and flies to the plant.

Knotted figwort Our commonest species is the knotted figwort, so called after its rootstock or rhizome, which is very thick and bears many knobs or nodes–a feature not present on other British figworts.

The knotted figwort is found in most parts of the British Isles, where it is common in wet woodland and shady hedgerows. It has no specific preference for a particular soil type. In height it varies between 45cm (18in) and 1m (40in), and the whole plant, with the exception of the inflorescence, is hairless. Some species of figwort have small wings at the angles of their square-shaped stems, but not the knotted figwort, although its angles are raised and thickened.

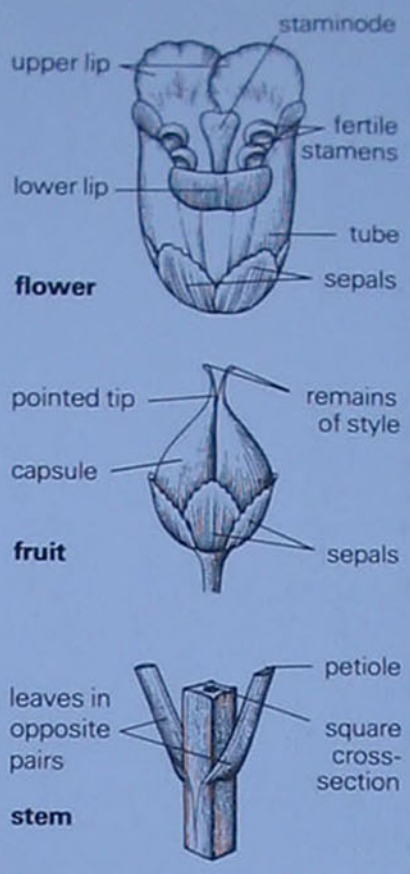
The leaves can be up to 15cm (6in) long and have toothed margins. The shape is ovate with a somewhat truncated base, which often tends to continue down the petiole (the leaf stalk).

Above: Our rarest native figwort is the balm-leaved figwort, which is confined to Devon, Cornwall and the Channel Islands. Its flowers are dull purple and its stems lack wings. The staminode is circular and has no notch.

Below: Yellow figwort (*S. vernalis*), an introduced species, flowers from April to June, which is much earlier than our native summer-flowering species. This is a hairy plant with yellow-green flowers.

Left: Flowers of the water figwort, showing stamens.

Right: The knotted figwort, our most common species.



Above: The flower, fruit and stem of knotted figwort.

The flowers are borne on slender stalks called pedicels, which may be several times longer than the individual flowers themselves. The flowers are arranged in cymes which are, in turn, borne in panicles. Each flower has a pale greenish tube about 10mm ($\frac{5}{8}$in) long with a reddish-brown, velvety upper lip. In the knotted figwort the staminode is regular in outline, broader than it is long and notched at the apex.

Water figwort Britain's second commonest figwort is the water figwort, also known as water betony. As its name implies, it favours wet places and is fairly common in damp woods and meadows and at the edges of streams, ponds and rivers. It occurs over most of the British Isles but tends to be rare in Scotland.

In general, the water figwort is similar to the knotted figwort, though it is a larger plant–occasionally reaching to a height of 1.5m (5ft)–with a proportionately thicker stem. The stem is also markedly different in having not just four angles but four wings at each angle. The leaves are similar in size and basic shape to those of the knotted figwort, though the petiole is winged (having a very narrow extension of the leaf blade running down each side) and may also bear a few lobes along the upper part.

The flowers are brownish-purple on the upper side and greenish beneath. The staminode is more or less circular in outline and lacks notches. The pedicels bearing the flowers are much shorter than they are on the knotted figwort.

Rarer figworts The other two native species are much less common than the knotted or the water figworts. Ehrhart's water figwort differs from all others in being completely hairless. Its stems have broad wings, as do its petioles. Its staminodes have two spreading lobes and are notched in the centre. Though rare, this species occurs over the length of England and into southern Scotland.

The balm-leaved figwort is a very rare plant, easily distinguished from other figworts by its covering, over the whole plant, of greyish hairs.

Native figworts

Knotted figwort *(Scrophularia nodosa)*

Water figwort *(S. aquatica)*

Ehrhart's water figwort *(S. umbrosa)*

Balm-leaved figwort *(S. scorodonia)*

NATIVE PONIES OF IRELAND

Connemara ponies still thrive in their native Irish habitat. They are known for their gentle, sturdy natures and their sure-footedness among rocks.

In that part of western Ireland which is lashed in the west by the great Atlantic Ocean, bounded to the south by Galway Bay and in the east by Loughs Carrib and Mask, lies the area known as Connemara. Here, in a land of rock-strewn mountains and valleys, bogs and islets, is found the native pony of Ireland, which takes its name from the region – the Connemara.

Ancient origins Today's breed has obscure origins; over the centuries it has absorbed the blood of Arabs, Andalusians, Thoroughbreds and even Clydesdales to develop into one of our larger native ponies. The modern Connemara stands up to 14 hands (142cm/56in) and is renowned as a handsome, sensible and versatile riding pony. Outside its native habitat it is bred on private studs all over the world, from Europe to Australia.

In Connemara the pony has for centuries been an indispensable part of the rural economy. Without ponies the farmers could not have gone to market or to Mass; they could not have tilled the land, gathered seaweed or carted stones to build the walls that enclose their small-holdings. Every small farmer once owned a few ponies. Even today they are still used as working animals and at a recent Clifden show (the principal Connemara breed show) one of the major prize winners was used in the plough when she was not in the show ring.

Today's ponies Although the breed is descended from ponies that roamed freely throughout Connemara, today they are managed rather differently. They do not usually run out on their native heath in herds in quite the same way as some other native breeds such as the New Forest or Exmoor. One reason is that most of the stallions are owned by the Connemara Pony Society, which entrusts them to individual farmers throughout the area. Instead of being turned out to run with the mares, the stallions are kept on the small-holding and either ridden or led round the district to cover their quota of mares during the breeding season.

When the stallion is not engaged in stud duties the farmer may use him for other purposes, provided he feeds him properly. Until very recently it was common to see a stallion and mare in double plough harness working in the fields or engaged in other jobs.

Every three years the stallions are moved to another district, so there is no danger of prolonged inbreeding and new blood is introduced to an area at regular intervals. Clearly, stallions used as working animals must have good temperaments, and the fact that all but the quietest and easiest animals are 'culled out' is put forward as one of the reasons for the delightfully equable and gentle nature of the breed as a whole.

Nevertheless, some stallions can cause problems. In Connemara the small-holdings are tiny and the fields are also small and bounded by rather inadequate stone walls. As the ponies are good jumpers, they were often 'hobbled' by farmers. This is not a particularly pleasant practice but it ensured the ponies more freedom than they would receive in a stall or stable. In some areas it is still used today. Tethering was even more

Above: A Connemara mare and (bottom) a mare with her foal. Constant grazing of rough herbage has ensured good, strong jaws.

Opposite page: Connemara ponies in County Clare Connemara stud.

CONNEMARA PONIES
Size 14-14.2 hands (142-147cm/56-58in).
Colour Mainly grey but also a variety of other colours.
Breeding season Between May and August.
Gestation About 11 months.
Number of young Normally one.
Lifespan 20-30 years.
Food Rough herbage, some heather, seaweed.
Distribution Connemara region of Galway. On studs.

widespread.

Small dispersed groups Although the stallions are rarely turned out, the mares frequently are, but as each farmer probably owns few ponies they tend to form not into large herds but into small groups of two or three adults and their followers – perhaps foals and yearlings. The vast area over which comparatively few ponies run reduces the serious worm problem found in some other ponies in mountain and moorland habitats, such as the New Forest; in these areas there is a far larger population within a small area, with consequent heavy worm infestation. If a farmer seeks a particular pony it may have wandered many miles and he frequently has to rely on information from someone who has been out on the mountain.

Bleak but hospitable habitat In spite of the rough terrain, Connemara is probably one of the least inhospitable of the natural habitats of native ponies in the British Isles. Because of the presence of the Gulf Stream, snow and severe frosts are uncommon, and the mean temperature is higher than that in most mainland habitats. The soil, too, although by no means of top quality, is better in many ways. The area is rich in phosphates, potash and carboniferous soils, and there are limestone valleys. Combined with the more equitable climate, this ensures a richer fauna and a reasonable growth of vegetation of acceptable nutrient value throughout the year.

The ponies graze the coarse grasses and eat lichens and sedges. Those near the shore find a favourite, and nutritionally valuable, food in seaweed – mostly species of *Fucus*. Gorse is eaten, particularly in winter, and many ponies grow luxuriant moustaches which protect their upper lips from the prickles. It is thought that in some ponies the upper surface of the tongue becomes thickened, as it does in New Forest ponies. The rugged terrain has meant that only ponies with short, strong legs have survived. This breed is thus noted for the quality of its bone.

Above: A mare rolling while a filly grazes nearby. It was a common practice to tether the ponies to prevent them straying. They have become so accustomed to this restriction that when they roll they habitually go down on one side, roll half-way over and then back. They then stand up and go down on the other side and repeat the performance, thus avoiding becoming tangled in the tethering line.

Below: The Connemara terrain is rough, strewn with massive outcrops of rocks and boulders. The ponies seek all possible protection from wind and rain.

In an area renowned for its bogs, the ponies must use their native instinct to avoid becoming trapped. Old books on the region tell of sure-footed ponies which instinctively avoided soft ground and picked their way through the rocky land with speed and safety. Just which of their senses warns them of boggy ground is open to speculation, but the people of Connemara are inclined to believe that the ponies' excellent sense of smell is involved.

Connemara ponies are famed for their homing instinct. If a pony is sold and moved from one end of Connemara to another it will frequently find its way back to its original home. It may take the animal some weeks, and the journey will frequently be accomplished at a walk, often with foal at foot, but it will nonetheless cross many miles of rough country to return home.

Changing hands Ponies change hands more today than in the past as they are bred less for farm work and more for sale to other breeders or exhibitors. Although some ponies are sold off the farm itself, the traditional way is still to take them to a fair. The best known is at Maam Cross.

There are no auctioneers at the fairs; all the deals are private ones, and there is an age-old ritual accompanying each one. The buyer sees an attractive pony and makes the owner an offer that is well below the likely price. The offer is rejected, and the prospective buyer goes off, usually to the nearest bar, and returns with an improved offer. The two bid and counterbid until a deal is finally struck. This is sealed with a slap on the hand. There is then an exchange of money – and the word 'exchange' is used deliberately. The buyer pays for his purchase, and the seller then returns at least part of the price as the 'luck penny'. The 'penny' is often much more than

that and might be as much as £100, but it is as much a part of the deal as the payment itself. The same custom is observed if a pony is sold from a farm.

Clifden Show One of the great pony events in Connemara is the annual show at Clifden, a small fishing village perched on the cliffs in the north of the region. Clifden is described as being 'like no other horse show in the world'. The show ground, although recently drained, is little more than a soggy clearing in the centre of the town, and although a small judges' box has been installed, spectators stand or sit on blocks of concrete that surround the area. People come not only from all over Ireland but from all over the world to watch and buy, for it is the true shop-window of the Connemara breed.

Anyone arriving the night before the show expecting to see ponies in the village is almost bound to be disappointed. But from the early hours of the following day the animals start to appear. They come in lorries and trailers, and dozens arrive down from the mountains, walking quietly along the lanes with their owners. Soon the village is a seething mass of ponies and spectators. Until recently most ponies appeared in the ring just as they came off the mountains – often rough, dirty and nearly always unbrushed. Lately, however, some local owners have started trimming the mane and plaiting it. The classes are enormous and 50-60 entries in a yearling class is not unusual. The show tends to be rather chaotic but it has a charm that is almost unmatched in the world of showing. After the show the ponies, still festooned with rosettes they may have won, and their owners, wend their way along the lanes. So Clifden is over for another year – a valued part of a way of life which, for the small-holders of Connemara, still revolves around their ponies to a large extent.

Above: Erriff river in Connemara, looking west towards snow-capped Benlugmore in November. The ponies are well adapted to this rocky, boggy terrain.

Below: The annual Clifden Show, Co Galway, the shop-window of the Connemara breed.

THE ANCESTRAL COMMON PEAR

The pear trees we cultivate in our gardens and orchards are the descendants of a wild species, the common pear, which is still found growing in Britain. Despite its name, however, it is now rare and confined mostly to the south.

Above: A common pear tree blossoming in a Warwickshire hedgerow. The pear produces its pure white blossom early in the year – usually in April or May – the leaves unfurling only when the flowers have begun to wither.

In the British Isles the rose family is represented by many colourful trees and shrubs, such as blackberry, hawthorn, rowan and various wild cherries. A much less familiar member of the family, though no less attractive, is the common pear.

Despite its name, the common pear has a restricted distribution in Britain, being confined almost entirely to the southern counties of England and Wales. In Ireland it is extremely rare, and it is totally absent from Scotland. In southern Europe and western Asia, however, the common pear is a much more frequent tree for it is better adapted to the warmer, drier climate of these areas.

In the wild, the common pear is a long-lived tree, usually found growing as an isolated specimen in hedges or on the margins of woodland. Less frequently, it is seen growing in a small group, as suggested by its scientific name, *Pyrus communis* – the epithet *communis* does not mean that the plant is common but that it is found in groups or communities.

Upright shape The wild pear is a deciduous tree but it can still be recognised in winter by its upright shape and distinctly pyramidal crown. Pear trees can attain a height of 15m (50ft) in as little as 30 years, but most specimens are somewhat smaller, usually in the range 6-12m (20-40ft). Immature trees have a grey bark which, with age, darkens to a deep blackish brown and becomes finely but deeply cracked into small squares.

A feature of the wild pear, not found in cultivated forms, is the presence of sharp thorns on the slightly hairy, brown shoots. The oval, pointed leaves are borne alternately on the twigs and do not emerge fully until after the flowers have begun to wither.

The flowering period is April and May, and the beautiful blossom is the most striking aspect of this tree. The flowers are grouped into clusters, each flower having a calyx of five sepals and five pure white petals, surrounding 20-30 dark red stamens. The stamens do not shed their pollen until well after the flower's stigmas have ripened, so preventing self-pollination.

False fruits The fruit of a pear tree is described by botanists as a 'pome' or false fruit since the fleshy part that is eaten is formed from the base of the flower's receptacle, whereas in true fruits the edible portion derives from the ovary.

The fruit develops into the characteristic pear shape but remains much smaller than cultivated pears, reaching a length of only 3-5cm (1½-2in). It stays green until about November and then turns yellow. An interesting feature of pear fruits is the presence in the flesh of dead, lignified cells; these are responsible for the gritty texture of a pear. The function of these cells is to protect the developing seeds from would-be predators.

Birds are probably the most important agents for dispersing the seeds. Once the fruits have turned yellow they become softer and slightly sweeter, and are palatable enough for birds to peck at the flesh and scatter the brown pips concealed inside.

Cultivated pears The fruits of the common pear are bitter and pretty well inedible, a fact reflected in one of the common pear's local names – choke pear. Despite this, it is the ancestral source of many cultivated dessert

and cooking pears.

Cultivated pears have an obscure origin, but they are probably hybrids between the common pear and two other closely related species, both native to central and southern Europe: *Pyrus cordata* and *Pyrus nivalis*. Selective crossing between these three species has given rise to the huge variety of orchard pears available to us today–for there are more than a thousand varieties now in cultivation. Pears have been cultivated for over two thousand years and the Roman naturalist Pliny, writing in the first century AD, noted that there were 39 different varieties being grown in his day.

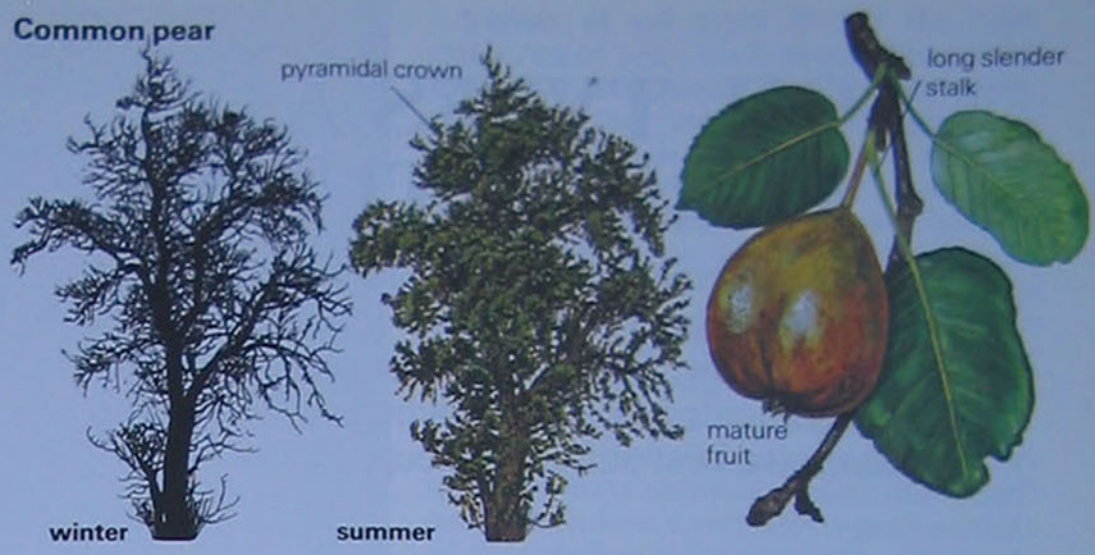
Modern cultivated pears are propagated by grafting the desired variety on to a vigorous rootstock, usually of common pear, though some other closely related species, such as quince, may be used. (Quince does not belong to the genus *Pyrus* but to the neighbouring genus, *Cydonia*.)

The common pear is also the ancestor of the hard, bitter pears used to make perry–a drink tasting rather like cider and made from fermented pear juices–which was probably introduced into Britain by the Norman invaders. Folk-names for perry–such as merrylegs and devil-drink–give some idea of its potency.

Perry orchards are found mainly in the south-west of England because of the mild climate of that area. In Gloucestershire, many of the older orchard pear trees are hosts of the parasite, mistletoe.

Prized timber Although not an important commercial source of timber, pear wood is favoured by sculptors and craftsmen for its fine grain and reddish-brown colour. It has great rigidity and so was once commonly used for making mathematical instruments such as set-squares. Pear wood is also much prized for carving; a fine example can be seen among the panelled walls of Windsor Castle.

Another interesting feature of pear timber is that it stains easily. In the past, this attribute was exploited by unscrupulous dealers, who used to stain pear wood black and then pass it off as ebony, a tropical hardwood which used to be very rare and expensive.



Common pear (*Pyrus communis*). Deciduous tree; doubtful native to Britain, more likely introduced from the Continent. Found mainly in southern England and south Wales. Height up to 15m (50ft).

Right: Pear flowers have the typical five-petalled structure of a member of the rose family. Outside the fruiting season pear trees look similar to apple trees, but they can be distinguished by their blossom: pear flowers have pure white petals surrounding a cluster of dark red stamens; apple flowers have white petals tinged with pink and much paler stamens. The two species can also be told apart by the much longer leaf stalks of the pear, and by this tree's more pyramidal, upright shape.

Below: A cultivated pear tree laden with fruit. Wild pears are smaller than cultivated varieties and more rounded.

Fireblight

Pear trees sometimes suffer from a serious bacterial disease called fireblight, in which the flowers die and the leaves turn brown but remain hanging on the tree. One Canadian scientist is fighting fireblight with the help of bees. He supplied their hives with a fungicide so that it could be distributed by the bees as they flew from one flower to another. The fungicide did the bees no harm and, as they searched for nectar they automatically deposited the chemical at the very point where the disease enters the tree–the nectaries.

SOIL TYPES AND AGRICULTURE

The soil a farmer happens to have on his land dictates, to a great extent, the type of crops he is able to grow. Barley, for instance, does well on a light, calcareous soil, whereas wheat and beans are best suited to deep, heavy land.

Below: Poppies in a field of barley. The problem with soil suitable for crops is that it is also excellent for weeds—particularly weeds of disturbed ground like these poppies. The poppy seeds which have sprouted so abundantly in this field were probably already in the soil before the barley was sown. In order to eradicate them, the farmer will have to spray the field with a selective herbicide the following year, before the poppies flower again.

For farmers the soil is not an ecological phenomenon but a piece of capital equipment; their concern is with the potential of the soil as a means of producing profit. Whereas the naturalist may be attracted to unproductive land for its specialised flora, to the farmer it is damned by its incapacity to bear a good crop.

Texture and particle size In the artificial conditions of an arable field, short-term fertility is a variable under the control of the farmer, but the essential texture of the soil is something which he can do little to influence. This is of fundamental importance: the capacity of the soil to hold water and dissolved plant nutrients—and consequently its seasonal behaviour, working characteristics and long-term fertility—is largely defined by the nature and size of the particles of which it is composed.

Soil consists of mineral material, in the form of stones, sand, silt and clay, mixed with the remains of plants and animals in varying stages of decomposition. Of the minerals, the stones, sand and silt are the result of physical weathering of the parent rock—impervious fragments which retain water and dissolved nutrients in a surface film. The smaller the fragments are, the greater is their total surface area. Therefore silt, which has a particle size of between 0.002mm and 0.02mm, retains very much more water, and correspondingly less air, than an equal volume of coarse sand (which has a particle size of 0.2-2mm).

Clay, which has an even smaller particle size than silt (less than 0.002mm) is formed by the chemical weathering of rocks by rainwater, which is weakly acid. It is distinguished by its ability to retain water within its porous particles, and by its tendency to cohere into large masses. Mixed with the other mineral material (the stones, sand and silt) in balanced proportions, clay binds the soil into granules, each containing soil water and plant nutrients, separated by air spaces into which plant roots may penetrate.

Heavy land Land that is heavy invariably contains a large amount of clay. When wet it tends to form clods of tightly packed material,

Above: Temporary pasture being ploughed-in. Such ploughing-in is done more to condition the soil than to restore plant nutrients to it.

Below: A crop of peas (with cabbages in the background) growing on rich black reclaimed fen peat.

or even a solid compacted layer which impedes drainage and root development. On the farm such compaction, known as poaching, may be caused by the weight of grazing animals or agricultural machinery. Used at the wrong time the plough itself may convert a wet but well-fragmented heavy soil into a series of clods lying on an impermeable 'plough pan' of smeared clay. Cultivation, which requires much power, must on this type of soil be restricted to the dry months. The technique of overwintering a rough-ploughed field is frequently used to allow the frost a chance to shatter the heavy clods.

The disadvantages of heavy land are balanced by its naturally high fertility, which is due to the retention of soluble plant nutrients in the substantial clay fraction. Furthermore, the restricted aeration of the soil slows the rate of decomposition of organic remains, and encourages their conversion into a dark, spongy cohesive material called humus. This contains all the nutrients taken up by the plants during life, and acts as a kind of slow-release fertiliser.

Light land Land that is light has a very friable structure for it contains little clay and may be composed largely of sand, which has no cohesive properties. Consequently drainage is very free. There is little risk of poaching, the soil may be cultivated without difficulty at any time of year, and it warms up quickly in the spring, promoting plant growth.

However, these advantages are offset by sandy soil's poor resistance to drought and a tendency to infertility. In the well-ventilated conditions organic material is rapidly oxidised by aerobic bacteria to form carbon dioxide and water. Liberated alkaline plant nutrients, such as calcium, phosphorus and potassium, dissolve in the acidic rainwater and drain away leaving, in the worst cases, a barren, inhospitable soil composed mainly of acid silica.

Variety of soil types Within the basic categories of light, medium and heavy land the farmer recognises a variety of soil types, defined by their most obvious features. In addition to the sandy soils, loams and clay soils already described, there are: stony soils, which are often fairly shallow and contain much unweathered mineral material from underlying rock or gravel beds; calcareous soils, which have developed from chalk or limestone bedrock and are often stony but normally fairly fertile; alluvial silts, in which the mineral particle size is intermediate between sand and clay and which, in consequence, behave rather like loams; and 'peaty' soils, which have a very high organic content of drained alkaline fen peat undergoing humification (humus formation). These peaty soils are extremely fertile but fugitive (quickly disappearing); the fen peat is a fossil resource under erosion from the combined effects of cropping and bacteriological oxidisation and is, in practice, unrenewable.

The wise farmer assesses his soil and crops it accordingly. Barley, for example, does well on a light calcareous soil. Wheat and beans, with their sturdy root systems and high nutrient requirement, are best suited to deep, heavy land, but where a high water table would inhibit root development, a shallow-rooted crop such as grass is a better investment. Oats and rye tolerate relatively poor acidic conditions, and for cash root crops,

such as sugar beet and carrots, a light soil which falls away during harvesting is preferred. Rich fenland soils are particularly suitable for valuable, demanding vegetable crops.

Improving soils by drainage Despite the range of crop options open to the farmer, modifications to the soil are often desirable in the interests of cropping flexibility. Although it is impractical to convert the soil directly from one type to another, various measures can be taken to influence its behaviour; these measures may make all the difference between 'marginal' land of little value and a useful addition to the farm capital.

Proper drainage is essential, even on light land, for crop roots will not penetrate waterlogged soil. Compacted layers of soil are broken up by means of a subsoiler, a simple tined (pronged) implement which penetrates well below plough depth and allows water to escape into the lower uncultivated levels. A build-up of standing water is prevented by installing a field drain network of earthenware or perforated plastic pipes set in gravel and leading to a main drainage channel or ditch. On heavy land the pipe drains may be fed by a secondary intersecting system of mole channels, formed by drawing a bullet-shaped 'mole' through the sticky soil.

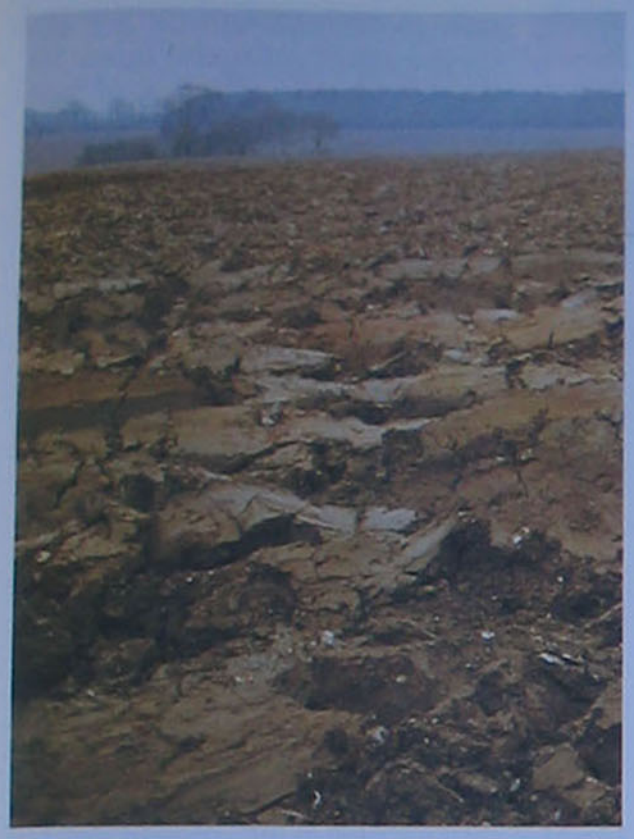
Improving the drainage inevitably accelerates the rate of nutrient-loss from the upper levels of the soil, and in a light soil the leaching effects can be severe. The direct answer to this problem is to add a cohesive material to the land in an attempt to bind the loose particles into nutrient-conserving granules. In the 18th and 19th centuries it was common to dress light soil with a calcareous clay called marl which, as well as retaining dissolved nutrients, inhibited the oxidisation and consequent loss of organic matter. The lime, or calcium, content corrected the acidity of the leached soil and also enhanced the granule-forming properties of the clay. While marling is rarely carried out today because of high labour and transport costs, liming of all types of land has remained an important feature of the farming year. Irrespective of its effect on the soil, calcium is a major plant food.

Above: Oil-seed rape, one of our most colourful crops, grows well on calcareous (chalky) soils.

Below: The excellent texture of this soil is immediately evident – it is neither stony, sandy nor waterlogged.

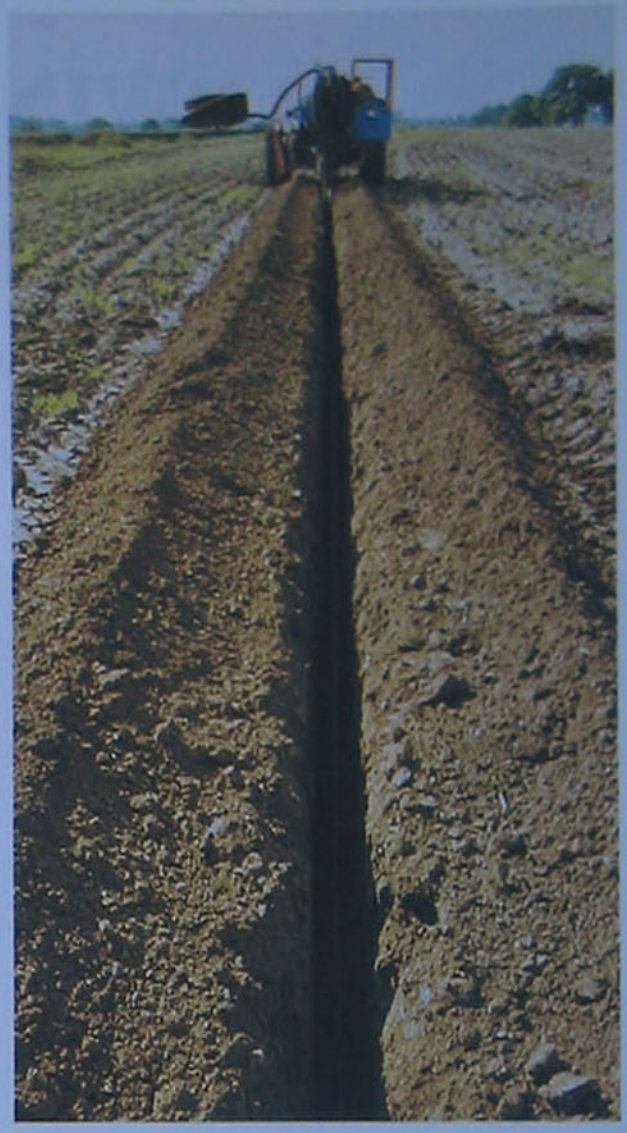
Organic manuring Another less permanent means of improving soil structure is organic manuring. For centuries this has been employed as a way of restoring plant nutrients to regularly cropped land, but today, with the nutrients available in a more convenient granulated form, the importance of organic matter as a soil conditioner has become more apparent.

Converted into humus, manure leavens clay and gives body to light soil, provided the quantity is sufficient to balance the effects of oxidisation. Consequently, many farmers periodically top up the humus level in otherwise chemically fertilised land by ploughing in animal manure, weeds and crop remains, temporary pasture or a specially grown 'green manure' such as lupins or white mustard. Mature cereal stubble is of little value in this connection, for it is mostly cellulose and not easily broken down; the dead roots, however, can make a useful contribution and modern minimum cultivation systems exploit this by using herbicides and stubble burning to clear the vegetation, leaving the land unploughed. Preserved from the oxidising effects of ex-



Left: Heavy clay soil. This is an overwintered rough-ploughed field in which clods have been formed by badly timed cultivation. This type of soil, which needs heavy machinery to plough it, should only be cultivated in the dry months of the year.

Right: Field drainage—pipe-laying in progress. Drainage can make all the difference between unusable, waterlogged land and soil quite capable of supporting a good crop.



posure, the cereal roots are sufficient to maintain the humus level of a moderately well-balanced soil, allowing cereals to be grown year after year without interruption.

Humification (the formation of humus) will only take place if the soil is well-populated with decomposing agents such as soil bacteria, fungi, arthropods and earthworms. In their absence organic matter persists in a barely modified form as peat; plant nutrients remain inaccessible and the soil-conditioning value of the material is greatly diminished. Drainage, manuring and liming measures owe much of their efficacy to the soil life they encourage, which in turn improves the structure of the soil.

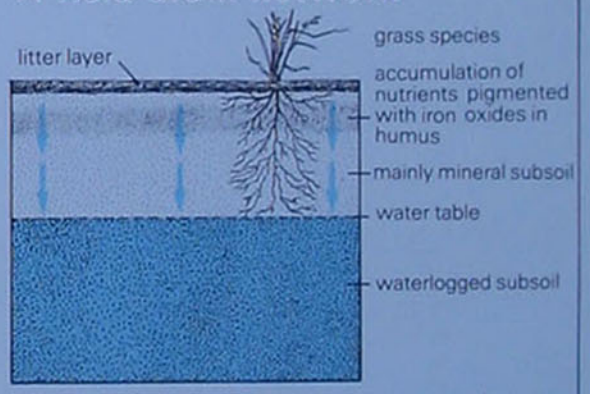
Below right: In uncultivated soil the nutrients derived from natural decay drain through the uppermost layers to accumulate in an ill-defined, organically rich area. If the same soil is drained water passes quickly through the artificial drainage system and the water table is lowered. The nutrients are concentrated in the ploughed topsoil. The compacted 'plough pan' is lifted and cracked by a subsoiler implement, which reaches deeper than a plough.

Below: Not all crops grow equally well on all soils. This chart is a general indication of which crops suit the different soils.

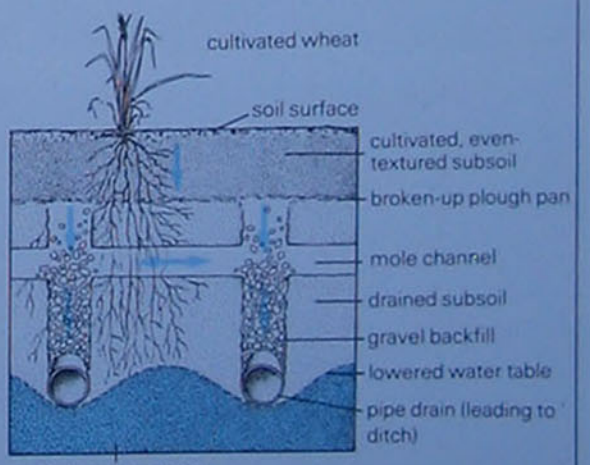
A chart of soils and crops

Light sandy soil		rye	barley	root crops	vegetables
Medium loam		SUITABLE FOR ALL CROPS			
Heavy clay soil		wheat	beans	grass	
Stony soil (non-calcareous)		winter pasture	rough grazing	forestry	
Calcareous soil		grass	clover	barley	seed crops
Alluvial silt (undrained)		permanent grass			
Alluvial silt (drained)		SUITABLE FOR ALL CROPS			
Peaty soil (acid moorland)		rough grazing	forestry		
Peaty soil (alkaline fen)		vegetables	flower bulbs	potatoes	wheat

A field drain network



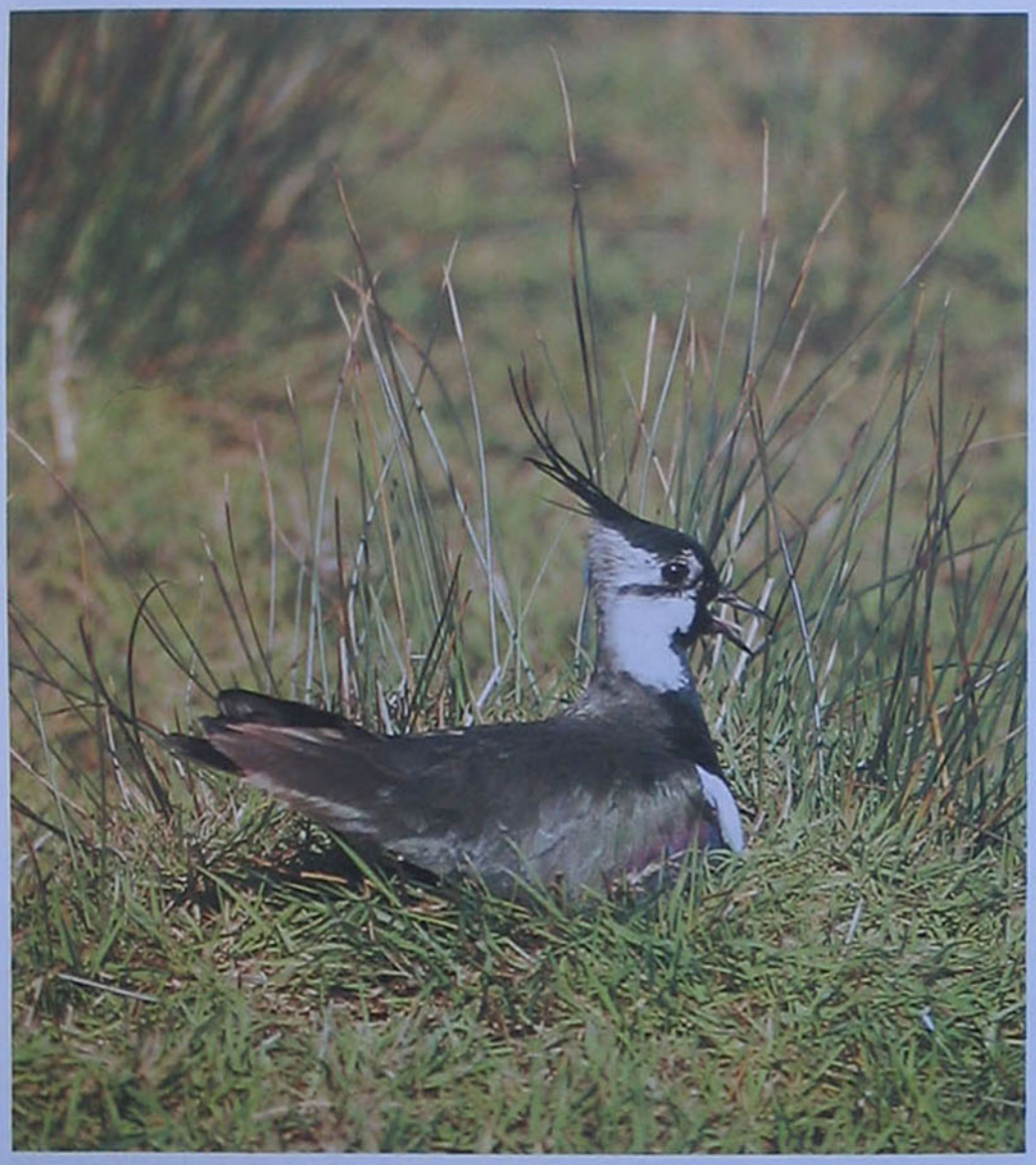
Above: Shallow-rooted weeds are all that can grow on undrained, uncultivated soil.



Above: Wheat, a long-rooted crop, will flourish on cultivated, drained soil.

LAPWINGS: TUMBLING FLIERS

The lapwing is one of the easier birds to spot in our countryside, with its distinctive crest and dark green plumage with white wing patches. It can be seen at all times of year, breeding on hillsides, marshes and farmland, or wintering near ploughed fields.



Peewit, green plover and lapwing are just three of a multitude of colloquial names for this particular bird, an indication of how diverse and confusing local names can be. Nevertheless, each name has a meaning: 'pee-wit' clearly comes from the plaintive rasping cry so familiar over meadows and marshes. 'Green plover', too, is a more appropriate name than would, at first, seem. Take a close look at this apparently black-and-white bird on a sunny day: the 'black' back is really deep bottle-green, shot with iridescent purple. Often you see lapwings in the air, when their floppy, clumsy looking wingbeats give a clear indication of how this, their most widely accepted name, was derived.

Lapwings are medium-sized waders, about as large as a pigeon but with the horizontal body posture and long legs of a wader. Besides their pied plumage, they have other useful identification features, such as the short beak and the slender, upturned crest, which is rather longer in the male than in the female lapwing. It is well worth seeking a closer look (using a car as a hide is an excellent idea) to appreciate the beauty of the crest and the sheen of the back feathers.

When they hatch, the young chicks are superbly camouflaged: the basic coloration of the down is a sandy fawn, with copious black or dark brown markings. There is a conspicuous white patch on the back of the head, easily seen when the chick is upright and running about, and doubtless an aid to its parents in keeping track of its whereabouts. When the chick squats, this prominent mark vanishes. As they grow, the chicks begin to resemble their parents, but with much reduced crests and with fawn fringes to the greenish-black back feathers, giving them a markedly scaly appearance.

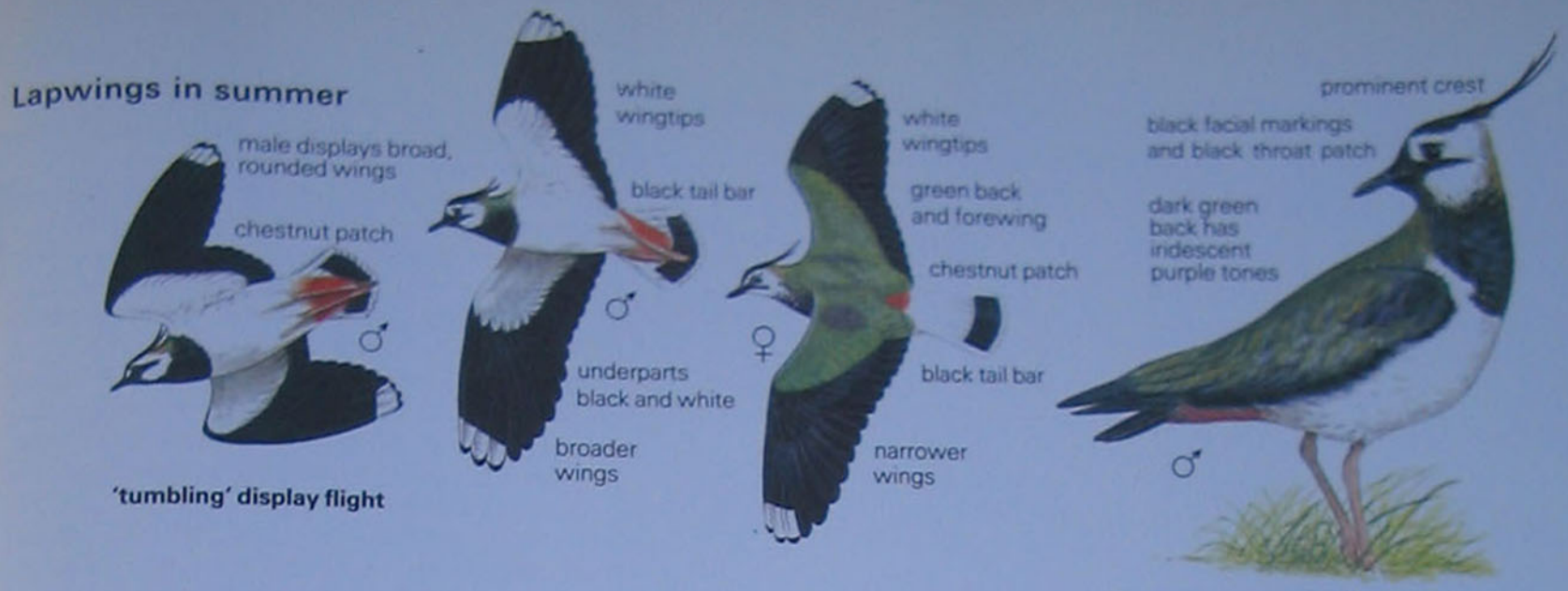
Many habitats Lapwings are classed among the wading birds, but unlike the majority of these their prime habitat is not the shore. Their short, typically plover-like beaks are ideal for catching small ground insects and other invertebrates. They often feed well away from the water, and in Africa many of their close relatives are birds of arid grassland.

In winter, most lapwings are found on

Above: A male lapwing incubating the eggs. Even a small tuft of rushes is sufficient cover for the lapwing's nest.

Left: The lapwing's nest is relatively elaborate for a wader, but the eggs are typical: irregularly blotched, and laid with their pointed ends inwards.

Right: When the parent bird gives an alarm call, the chicks squat down to hide in the grass.



damp grassland or ploughed fields, with relatively few on the moors. They occasionally visit the shore, but usually only when snow or hard frost has made feeding difficult inland. On farmland, it is amazing to see how a flock of such conspicuously black and white birds can apparently vanish into the ground when they land. Their food at this time includes a great many worms and insect larvae driven out of the soil by the shallow flooding associated with winter rainfall. Often, lapwings congregate in flocks, sometimes hundreds of birds strong, but towards the end of winter these flocks begin to fragment as migrants return to their breeding areas overseas and as local birds begin to take up their territories.

Lapwings breed in a considerable range of habitats, but these do have a common feature: the territories always have patches of short vegetation or bare ground nearby, suitable for feeding. In some areas, most breeding birds are found on waste or marginal land, such as that surrounding gravel pits, chalk quarries, refuse tips or sewage farms. Elsewhere, they are farmland birds, breeding on permanent pasture or on freshly ploughed land sown with winter or spring corn. In upland areas, lapwings tend to congregate in the more sheltered situations, rather than on the moors. They usually set up their territories in the valleys, where any arable farming also tends to be concentrated, so improving the range of feeding habitats available.

Defending the home Territories are easily recognised as the air overhead in spring is full of tumbling, calling birds performing their aerobatic displays. Besides the calls, the wingbeats themselves are audible: the rounded, 'fingered' wings of the lapwing produce a unique 'whooshing' noise. Interestingly, male and female can be told apart at this time by the width of the wings: with the major role to play in display, it is natural that the male's wing is noticeably broader and thus noisier. Wing noise is not just used for display, but also as a terror weapon to repel invaders of the pair's territory.

Ground-nesting birds are vulnerable to attacks from predators–magpies, crows and foxes–and any marauders, even humans, are instantly attacked by both birds as they cross the territorial boundary. The swooping, screeching lapwings, with these thumping wingbeats, are usually enough to put off any intending predators and thus increase the chances of the eggs being unharmed and the young surviving. It need not be the threat of losing in combat that deters the predator, for if there are other good hunting grounds nearby that are free from the distracting noise and behaviour of lapwings, the predator simply takes the easier option and hunts elsewhere. It is the aggressive appearance of the lapwing, rather than its fighting capability, that keeps danger away.

Often quite innocent parties become involved, and the sight of a pair of partridges straying accidentally into a lapwing territory while feeding, and then attempting to withdraw and maintain some dignity under such an onslaught, can be extremely amusing to watch.

The breeding season The lapwing's breeding

Above: The breeding plumage of the lapwing. The pied plumage proves, on closer inspection, to be a combination of black on the outer part of the wings, white mainly on the undersides and bottle-green with iridescent purple tones on the back. The winter plumage is similar to the summer plumage, but looks mottled, for many of the feathers have buff edges.

Lapwing (*Vanellus vanellus*). Wader adapted to inland habitats including farmland and upland meadows. Resident, with additional wintering population from Europe. Length 30cm (12in).

Below: A small flock of lapwings over a ploughed field in winter.

behaviour is, in many ways, typical of all the wading birds. The nest, at first, is a mere scrape in the ground. The male makes several of these, using his feet to do a little excavating and then his breast to round off the hollow. The female chooses one of these nests, which both birds then line with fine, dry grasses. Almost always it contains four eggs, though on rare occasions clutches of three or five are found. The eggs are stone-coloured, with copious black blotches giving excellent camouflage, and are arranged points facing inward in a neat square.

The sharply pointed shape of the eggs is characteristic of most waders, and has a logical explanation. Young lapwings hatch down-covered and with their eyes open, and as soon as they are dry they scamper around, feeding themselves under the watchful eyes of their parents. To do this, they must have well-developed and relatively long legs, and it is these that are housed, compactly folded, in the pointed part of the egg.

Both sexes share the work of incubation, which lasts about a month. Although the sitting bird may seem conspicuous in the middle of a field, it is likely to leave the nest and go into hiding if danger appears: once the bird has gone, the eggs are so well camouflaged that they are difficult to find. During the five weeks that it takes the chicks to fledge, each parent may take responsibility for part of the brood. Alternatively, the female may shepherd them about while the male stands guard.

A nomadic bird The movements of the lapwing lack the routine patterns that are characteristic of migration, and might, therefore, better be called nomadism. After the breeding season, the birds disperse widely. A lapwing may not necessarily breed in the same area in successive years, nor does it always migrate to the same wintering areas. Young birds bred in Britain or Ireland are as likely to be found nesting the following spring in central Europe as in the country of their origin.

This nomadism may be a factor that has prevented the species from subdividing into distinct regional groups (subspecies). This effect is seen in several widespread bird species: one example is the yellow wagtail, subspecies of which occur in different parts of Europe and Asia. The lapwing's distribution also extends into Asia, but it is thought that the bird's nomadism helps to mix the stock together, thus preventing a separation into distinct groups.

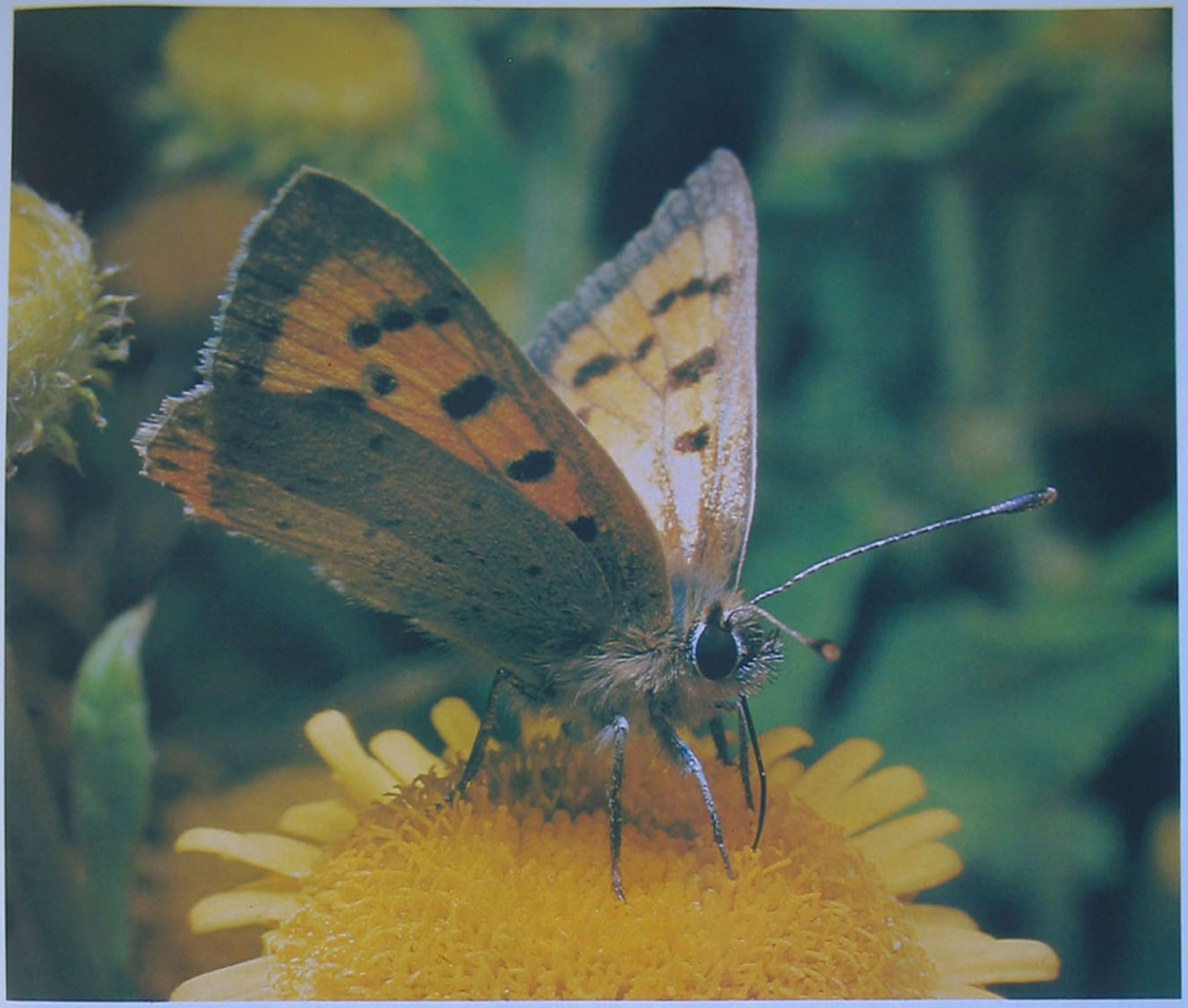
In winter, lapwings in Britain and western Europe react very quickly to changes in the weather. Any really cold spell is usually heralded by flocks of lapwings, flickering black and white across a stormy sky, heading westwards in the hope of finding warmer weather. If the cold is short-lived, a return movement may be seen as soon as the thaw sets in.

Lapwings are our most widespread species of wader, and are among the most numerous members of this group, in both summer and winter. Winter numbers depend greatly on their nomadic wanderings, and on the weather, but are always greater than those in the breeding season. Various estimates have put the breeding population in the region of 200,000 pairs, a figure that drops sharply after a very cold winter.

In the north of Britain, breeding numbers are on the increase, while in the south (probably as a result of land drainage and other changes in cereal production), some areas show signs of a decrease. Thus there are indications of a geographical shift in the population, though the total numbers are not changing.

Above: A flock of several hundred lapwings lifting off from a winter field. Lapwings on the wing usually form ragged and shapeless flocks. Towards the end of winter these flocks begin to fragment: some birds are migrants from further north, and these return early in the year. Non-migrants depart to take up their breeding territories for the new season.

Below: A male lapwing broods the chicks: his dark throat is clearly visible.



HEATHLAND-LOVING BUTTERFLIES

Britain's heathlands provide a suitable home for four species of butterflies–the wall brown, the small heath and the grayling (all members of the Satyridae or 'browns' family), and the small copper which belongs to a separate family, the Lycaenidae, and is our only surviving 'copper' butterfly.

The four species of butterfly considered as regular members of our heathland communities encompass a wide range of lifestyles and habits which enable them to utilise many other habitats. For this reason they are by no means confined to the heathlands of Surrey, Hampshire and Dorset.

Distribution The small heath is possibly our most common butterfly since it is found throughout the British Isles–except Shetland and Orkney–from sea-level to mountains 610m (2000ft) high. The small copper has a similar distribution although it is absent from the north of Scotland and mountainous regions. The wall brown occurs in a wide range of habitats in England, Wales, Ireland and southern Scotland, while the grayling has been recorded in most counties in England, as well as in Wales, Scotland and Ireland. It appears, however, to prefer coastal

Above: The attractive small copper (*Lycaena phlaeas*) is our only remaining representative of the coppers (the large copper became extinct in England in 1848). Despite the small copper's size–its wingspan is a mere 2.5cm (1in)–it is a conspicuous butterfly as it darts rapidly from its favourite perch to challenge any intruder to its territory. When not defending its territory, the male visits flowers such as this composite, or brambles or marjoram, where it sits with its coppery-brown wings half open. It is common in most habitats throughout the British Isles, except in the far north of Scotland and high mountainous regions.

and heathland areas, where the climate is warmer and drier.

The limitations to the distribution of these butterflies are not really understood, but the foodplant and climatic factors are thought to be important. Since the three browns – the wall brown, grayling and small heath – feed on grasses, each species preferring a certain type of grass, this could partly explain their distribution, especially the grayling's preference for warm, dry coastal and heathland sites.

Variable graylings Although the small heath, wall brown and small copper do not differ markedly in appearance throughout their range in Britain, the grayling has evolved several distinct subspecies in response to differences between localities. In Scotland and Ireland individuals are noticeably brighter than their English counterparts, while the graylings found on chalk downland are paler than those occurring on heathland. Most unusual of all is the dwarf race called *thyone*, found only on Great Ormes Head in North Wales, where it flies earlier than the neighbouring 'normal' grayling colonies.

One possible explanation for the great diversity in the grayling's colouring lies in the adult's means of defence. The under-surface of the grayling's hindwings is subtly patterned with shades of grey and brown in stark contrast to the bright orange brown colour and prominent eye-spots of the other wing surfaces.

When the grayling alights it behaves in a similar manner to the mountain ringlet; the eye-spots attract any potential predator – a bird or a lizard – to the wings, thus deflecting attention away from the butterfly's body. Once satisfied that no attack is imminent, the grayling folds its wings, and disappears against the sandy or rocky background. This disappearing trick is aided by the butterfly's habit of tilting its wings over towards the ground, and avoiding any shadows.

Since the butterflies must be perfectly camouflaged in each locality, they adapt to changes in ground colour by evolving matching shades of brown. Thus the chalk downland graylings have pale undersides to match the chalky soils, while the heathland varieties are darker to blend with the black peaty soils usually found in these habitats.

Sandalwood scent The male grayling is distinct from the female in its possession of a dark-coloured scent band on the forewing. The smell emanating from this band plays an important role during courtship and has been likened to the fragrance of sandalwood or cigar boxes.

The grayling has only one generation a year, the female laying her pearl-like eggs singly on grass blades where the resulting caterpillars feed at night. The chrysalis is unusual among British butterflies in being brown, and resembles the pupa of a moth – it is concealed about a centimetre below the

Above: The adult of the small heath butterfly (*Coenonympha pamphilus*) feeds on low-growing flowers, such as clover, tormentil and bird's-foot trefoil. When resting or feeding on flowers it keeps its wings firmly closed over its back to conceal its brightly coloured upper wing surface. The under surface of the forewing has a large clear eye-spot (seen in the picture) which may be hidden behind the dull greenish-grey hindwing when at rest. The adults may be seen on the wing from May onwards.

Right: The male wall brown (*Lasiommata megera*) is easily distinguished from the female by its smaller size and the broad black scent patch which runs diagonally across the forewings (seen in the picture right). This scent patch is the source of a chemical aphrodisiac used during courtship – to humans it vaguely resembles the smell of chocolate.

Caterpillar shapes

In contrast to the 'normal' elongated shape of the wall brown, small heath and grayling caterpillars, the larva of the small copper and other lycaenids is compressed into a roof-like shape. Along the 'eaves' of this roof-shape there is a fringe of hairs which hides the legs and enables the body to blend with the surrounding leaf surface. Even its head is concealed beneath the body, giving the caterpillar a slug-like appearance. As the small copper caterpillar (right) feeds on the undersides of sorrel leaves, the combination of shape and subtle colouring makes it well camouflaged.

ground, in a loose silken cocoon. The adult butterflies appear in mid-July, but fly only if disturbed, moving in short, rapid bounds.

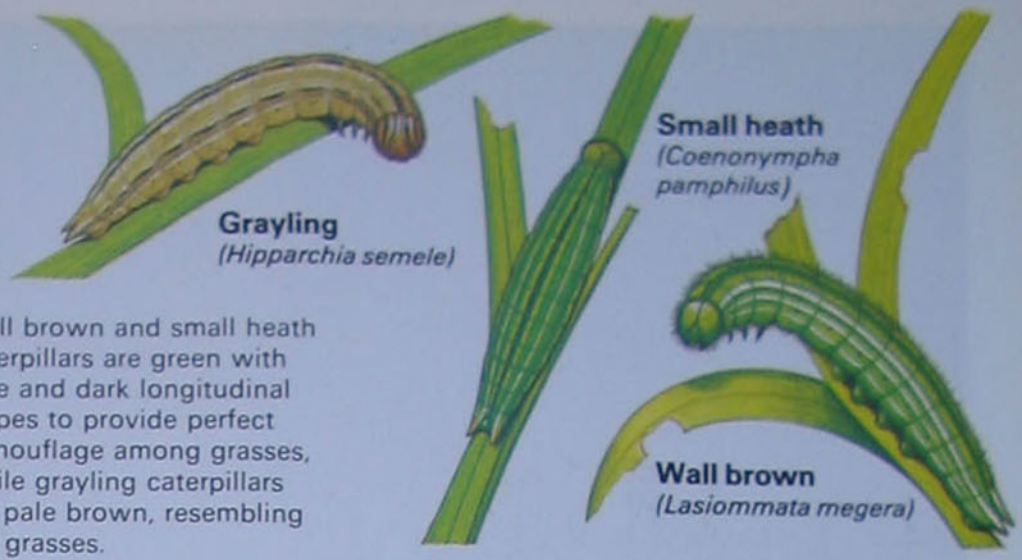
It was once thought that the grayling did not visit flowers, and was attracted mainly to tree sap, but recently a coastal colony of graylings has been observed feeding regularly on thyme.

Small heath butterfly Another member of the Satyridae, the small heath butterfly is orange-brown in colour, the female being slightly larger and paler than the male.

As a rule there are two generations a year, although this can extend to three during a long, hot summer in southern England. The female lays her brown and cream eggs singly on fine blades of grass. The pale green caterpillars, which feed at night, eventually develop into pale green chrysalids with black streaks on the wing cases; they are suspended from stalks within clumps of grass. The adults emerge in mid-May after passing the winter as caterpillars in a dormant state. A second brood is usually seen in late July.

Wall brown As a sun-loving species, the wall brown is usually found basking on bare patches of soil on heath and downland, and on walls in hedgerows and lanes. Its flight is quick and restless as it flits from flower to flower or between basking sites. This activity is misleading for, despite its lively manner, the wall brown usually confines itself to a particularly small area throughout its life–a fact discovered by placing small ink marks on wings of individuals and then noting their positions from day to day.

When laying her eggs, the female chooses grasses which grow in straggly strands around rabbit burrows and hollows in the ground. The caterpillars are mainly night feeders, and have no true hibernation state, merely becoming torpid in winter and feeding in mild weather. The chrysalids, which form on the grass plant, are variable in colour, ranging from green to brown. In mid-May the first brood of wall browns appears, with the next following in August or September.



Wall brown and small heath caterpillars are green with pale and dark longitudinal stripes to provide perfect camouflage among grasses, while grayling caterpillars are pale brown, resembling dry grasses.

Above: The grayling's appearance varies according to its habitat because of the need for camouflage. While the heathland grayling (shown above) is dark to match the peaty soils, the chalk downland populations tend to be paler.

Heathland blue The small copper, a member of the Lycaenidae, or 'blue' butterflies, is a delightful insect, brilliant in colour and sparkling in flight. Despite its small size, it is remarkably conspicuous as it rapidly darts around, defending its territory and visiting flowers, particularly composites (members of the daisy family). To butterfly enthusiasts, the picture that comes to mind when the small copper is mentioned is of a brilliant, metallic copper butterfly with its wings half open, sitting alert on a daisy head.

Unlike the previous three species, which all feed on grass, the caterpillars of the small copper feed on sheep's sorrel and common sorrel plants. It is on these plants that the female lays her minute golfball-like eggs. The caterpillars are so well camouflaged as they lie on the undersides of the leaves that it is almost impossible to find them.

On becoming fully grown the caterpillar spins a silken pad on the underside of the leaf, with a silken girdle for support. It either overwinters when small, or when half-grown, depending on the timing and the number of generations in the previous year. The first adults are seen in mid-May and are followed by other generations in July and September.

Above: A bleak sight confronts the gamekeeper: the fox has found its way into the laying pen and taken 68 pheasants. Foxes are tireless predators of all game birds, especially in winter when other food is scarce. Although a relatively flimsy structure will keep pheasants in, it will not keep predators out, and the gamekeeper must ensure that there are no weak points in the pens that foxes, weasels or stoats may penetrate.

RESTOCKING THE LAND

Game birds are reared primarily for sport, although many never fall to the gun. They thrive in specially managed habitats that also encourage other widlife.

The shooting of game in the British Isles has a long history. Long ago man shot birds because he needed food, but by the 18th century rough shooting was a fashionable pastime for the rich. The rearing of birds specially for shooting began in the early 19th century; it continues today, and it prevents the destruction of much of the countryside by modern agriculture for the simple reason that game birds cannot survive in huge, hedgeless fields in areas without woodlands.

Game birds thrive in habitats which are highly hospitable to other forms of wildlife: mixed cover of hazel or chestnut coppice, for example; some tall trees such as oak, ash or larch, perhaps protected from winds by spruce; and plenty of undergrowth which gives the birds additional food and warmth.

By ensuring that woodlands are coppiced regularly to promote a healthy shrub layer of perhaps holly, honeysuckle, bramble and elder, the gamekeeper also encourages a profusion of other wildlife, including carpets of spring flowers and a rich insect, bird and mammal population, all of which simply could not survive in overgrown woodland or areas of huge, featureless fields. All kinds of birds nest here: woodpeckers, wrens, wood pigeons, tits, warblers, finches and owls, to mention just a few.

Field sizes tend to be smaller. Copses, spinneys and patches of scrub at the corners of

fields are encouraged, not cut down to make extra field space. Marshy patches with stands of reeds and willows remain undrained and attract wild game such as woodcock. As a result a farm managed with the interests of game in mind looks very like the patchwork of fields and woodlands we associate with the traditional English countryside.

Partridges During the last 20 years or so the partridge population has declined because of modern agricultural practices, which do not give sufficient or suitable cover. In most areas it is uncommon today to see a covey (family party) of grey partridges skimming over the hedgerows, but where they are still widespread it is probably because gamekeepers have taken great trouble to provide a habitat which encourages them to nest. The birds nest on the ground, often beneath a mature, well-drained hedge in areas with protective undergrowth that includes grasses and many other plant species, as well as dead herbage. They find food on nearby grassland, cereals, root-crops and fallows and, since they are fairly reluctant to fly, they depend on this type of low vegetation to help them escape from predators. Such areas are also extremely hospitable to other forms of wildlife, particularly birds and insects.

A further problem faced by partridges is the use of chemicals on crops; crop-spraying reduces the number of insects available to young chicks. Their diet includes plant bugs, leaf hoppers, caterpillars, weevils, aphids, ants, sawfly larvae and some beetles. Many of these insects feed on cereal aphids, but when there is intensive crop-spraying the food of the chicks declines. Good partridge habitat thus minimises the use of insecticides. Wet summers are also disastrous for the chicks because the right food is not available when they need it and their downy coats become wet, offering little protection against the cold.

However, in many areas the partridge numbers have been greatly helped through re-stocking by gamekeepers. On a well-run partridge 'manor' a keeper aims to stock at up to one pair every four hectares (10 acres). Chicks (known as 'poults' after six weeks of age) are bought from hatcheries to be released into the wild as soon as the harvest is over; gamekeepers hope that the youngsters will stay together in the coveys natural to partridge families.

The gamekeeper works closely with the farmer to keep partridges on their territory. Together they plan blocks of such root crops as sugar beet. They leave the stubbles for as long as possible, and plant crops such as maize, sprouts and oilseed rape. The aim is to ensure that the coveys do not stray to areas where they may encounter unwelcome pred-

Above: A cock pheasant. The pheasant, our most prolific gamebird, owes its great success to the fact that it is bred extensively for shooting. Roughly a third of reared birds are shot, and the rest roam the countryside in greater numbers than ever before. The gamekeeper tries to encourage the birds to remain on his land by providing a steady supply of food, and good cover which includes layered woodland that is well protected from prevailing winds and contains water and some cultivated ground.

Right: Corpses of predatory birds, most of which belong to the crow family. Carrion crows and magpies are ruthless and accomplished assassins, taking not only the eggs and young of gamebirds but those of numerous songbirds as well. Gamekeepers search for and destroy their nests in deciduous woodlands in February and March. Although this prevents predation on game, it also saves many songbirds from premature death.

Left: A red grouse cock in early spring. It lives mainly on the ground among heather. A well managed grouse moor offers heather of all ages for food and protection.

ators. Winter feeding is time-consuming for the keeper, but partridges return again and again to take food put out for them in sunny, sheltered areas, especially rough ground.

Pheasants One of the most successful introductions to the British Isles is the pheasant. No forest ride would be the same without a cock pheasant striding haughtily across it, golden feathers flashing in the sunlight; and there would be even fewer hedgerows in East Anglia if it were not for sporting interests, for pheasants, like partridges, need hedges for cover and nesting.

The home ground birds usually form the basis of an annual restocking programme. The keeper catches the hens from Christmas onwards, and they pass the rest of the winter in a stock pen, with every comfort from windbreaks to high grade food. In March they are moved to laying pens with one cock pheasant to every six hens. As the hen lays, the keeper removes the eggs – he can incubate them much more successfully than the hen, and she may lay up to 40 replacements. The eggs are put into an incubator after washing and fumigation.

Above: A red-legged partridge. This species often lays two clutches of eggs each year, the second being incubated by the cock. Like all game birds, partridges respond to winter feeding and the provision of suitable, sheltered habitat.

Below: Partridge chicks are hatched by incubator and the chicks are reared in heated brooder units. When they are about a month old they are moved to outside runs where the gamekeeper must look out for predators. Raising partridges is not easy. The keeper must watch for coccidiosis, a fatal disease if not treated in time. Feather picking is prevented by temporarily fitting the beaks with plastic bits.

When the poults are six or seven weeks old they are moved to rearing pens where their beaks are fitted temporarily with plastic devices to prevent them from picking each other's feathers. Initially the birds' primary feathers are clipped to stop them flying away and each bird is tagged to provide the records that are vital guidance for the keeper in future release programmes. By August, assuming they have received sufficient food and water and that they have escaped predators, particularly foxes, the birds are ready to be released into the wild.

So much care and attention will have been a waste of time if the poults are not released into a hospitable area. The birds roam the fields and hedgerows for food, taking crops such as kale and maize. As winter progresses they rely on grain from hopper feeders or 'scratching heaps', often sited alongside a covert.

Grouse Many gamekeepers say that the red grouse, not the robin, should be the British national bird because it is the only British bird species that occurs here and nowhere else. It is mainly confined to heather-covered hills and moors. From the keeper's point of view it is different from the partridge and pheasant because it cannot be reared in captivity and released. Each young grouse must be raised by its parents, thus the keeper's overriding concern is that the condition of the moor should ensure breeding success. A

Salmon and trout for game

It is usually water bailiffs and ghillies rather than gamekeepers who look after the rivers that provide us with some of the world's most exciting trout and salmon fishing. Coarse fishes (any fishes that are not members of the salmon family), which attract predators that also attack trout and salmon, are prevented from entering the river by nets stretched across the tributaries; the river plants are also cut back to reduce hiding places and give easy access. Water bailiffs must ensure that the water quality and levels are as good as possible to encourage the fishes to breed; they restock the rivers with brown trout and—a more recent development—with hatchery-raised salmon. Salmon lay their eggs in the same area in the river in which they themselves were hatched, and it is hoped that hatchery-raised salmon will return in time to breed in the place they were first released into the river. Although trout are fairly plentiful, the Atlantic salmon is a declining species, and its life history still remains much of a mystery. Trout fishing is increasing in fisheries and reservoirs.

Left: Angling for brown trout in Loch Awe, Argyll in Scotland.
Although some birds such as the cormorant, goosander, red-breasted merganser, heron and others prey on game fishes, poachers are much more of a problem and a water bailiff must be vigilant in patrolling the countryside at dawn to catch the culprits. The mink and otter are two less common mammal predators. Game fishing is expensive and, in the case of salmon, difficult to obtain.

poorly managed moor encourages grouse disease (strongylosis), which is responsible for periodic high levels of mortality in grouse.

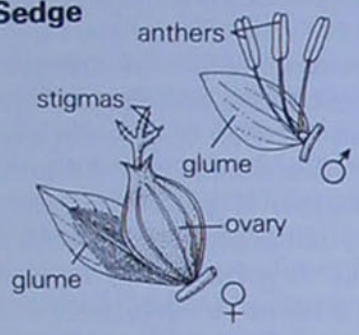
The keeper provides heather of different lengths for the grouse to eat and parts of the moor are burned in rotation to give variety. Long heather provides shelter and warmth, medium growth heather is good for nesting and young heather, rich in protein, is essential food for the chicks in spring. This type of habitat also offers a home to such species as the mountain hare, red deer and a number of birds of prey, including the buzzard, the golden eagle, the peregrine, merlin and kestrel, while many small insects feed on the plants' sap.

Good pheasant country

1 conifers planted as a wind-break
2 unburnt stubble
3 scrub at field edge
4 hopper provides food for birds in winter
5 pond
6 maize and kale sown in strips for forage value
7 hedgerow offers shelter and food including insects and berries
8 corrugated iron shelter gives protection from rain
9 wetland plants give cover to other species such as woodcock and snipe
10 copse containing deciduous trees and shrubs provides abundant food and cover

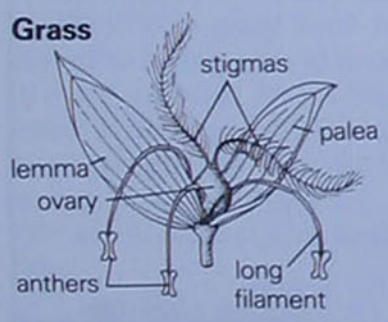
Right: One of the few sedges to form large stands in Britain is the greater pond sedge (*Carex riparia*). It can grow to a height of 1.3m (4ft) and is found by the sides of slow-moving rivers, in ditches and around ponds, its base often immersed in water. Each plant bears a number of flower spikes, the upper ones male and the lower ones female. Compared with the spikes of some other sedges, those of greater pond sedge are fairly plump.

Sedge



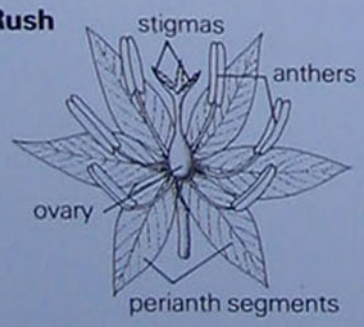
Above: Male and female sedge flowers are borne separately. On the males the anthers are joined rigidly to the filament.

Grass



Above: Grasses have male and female parts on one flower, male parts having a characteristically long, flexibly jointed filament.

Rush



Above: Rushes also have male and female parts on one flower, each bearing six anthers and six perianth segments.

SEDGES: SEASHORES TO MOUNTAIN TOPS

Superficially similar to grasses, but with a quite different flower structure, sedges have evolved into a bewildering array of species–more than 70 in Britain alone, in habitats ranging from the seashores to mountain tops. Yet, despite their ubiquity, sedges remain overlooked by the casual observer.

Grasses, sedges and rushes are three quite distinct families of plants, though at first sight they are not easily told apart. All are inconspicuous green herbaceous plants with very much reduced, wind-pollinated flowers. The rushes are the most easily distinguished because they do, at least, have recognisable flowers which are rather like those of a lily in having six petal-like structures, the perianth segments.

Grasses and sedges, on the other hand, have a complex arrangement of floral organs, often difficult to relate to a conventional flower. Individual grass flowers have, with very few exceptions, both sexes present but sedges have separate male and female flowers. The two groups also differ in the arrangement of their leaves and the shape of their stalk. When viewed from above, the leaves of a grass are seen to be arranged in two ranks on a cylindrical stem; on a sedge the leaves are arranged in three ranks around a stem that is often triangular in cross-section.

A sedge flower consists of little more than the reproductive organs and a subtending scale–the glume. The flowers are gathered into more or less cylindrical heads called spikes.

The sedges can be divided into three groups according to the structure of the spikes and the distribution of the male and female flowers. In the first group, the spikes all look the same, whether they bear purely male or female flowers, or are mixed–if mixed, flowers of opposite sexes are borne at opposite ends of the spike. In the second group of sedges, each

spike bears flowers of just one sex, male spikes looking quite different from female spikes. Lastly, there is a small group in which each plant bears only one spike.

Similar spikes The first group of sedges numbers about 20 British species, of which one member is the sand sedge. Being in the first group, this plant has spikes that all look alike, those towards the top of the plant being single-sexed and the ones at the base bearing both sexes. The spikes are closely set in a tight lobed head. This species is restricted to fixed dunes and wind-blown sand, and is one of the few sedges to dominate large areas of a habitat.

Spiked sedge is similar to sand sedge, having a number of short spikes gathered into a head. However, whereas sand sedge sends out underground rhizomes that put up solitary shoots every few inches, spiked sedge has very short rhizomes that make the plants appear densely tufted.

Another densely tufted species in this first group is remote sedge, but it is as different from the sand and spiked sedges as could be imagined. Its spikes, instead of overlapping in a tight head, are widely spaced along the upper half of the stem, only those at the very top being at all close together. The spikes of this species carry long slender bracts, those at the base of a plant being far longer than the tip of the spike. Remote sedge inhabits damp shaded places with an acid soil.

Group two species The second group of sedges comprises almost 50 species, of which one of the most familiar is the pendulous sedge, not because it is common but because it is often grown in gardens. This species forms a huge, tussocky plant with clumps up to 70cm (30in) across and stems up to 1.8m (6ft) tall. Each flower head carries one or two male spikes and four or five female ones.

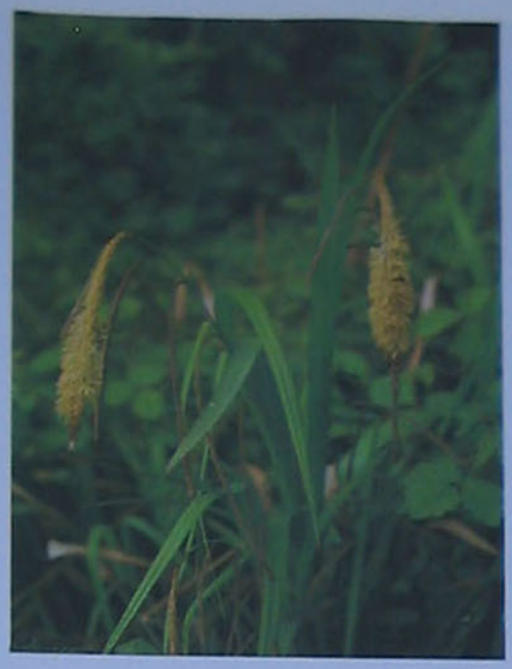
In the wild, pendulous sedge is typically a woodland species, a habitat it shares with a another species of sedge belonging to the second group, the wood sedge. This species usually has one male spike and three or four female spikes on each slender stalk.

Hillsides and hedgebanks Grassy hillsides and hedgebanks are the usual homes of Britain's most distinctive sedge, the hairy sedge. A member of the second group of sedges, this species is conspicuously hairy, our only sedge to be so. It is common throughout the British Isles, except in the far north and in areas with exceptionally high rainfall.

The hairy sedge is often joined in its habitat by two other sedges – the common sedge and the glaucous sedge. The common sedge is a widespread species, preferring wet grassy places and watersides. It has a quite remarkable colour scheme. The glumes of both male and female flowers are purple to black with a pale line down the middle; the fruit is also purplish or sometimes green, and the leaves have a bluish tinge.

Glaucous sedge also has a bluish tinge to its leaves – as its common name implies. However, a closer look at the leaves shows that only their undersides are glaucous, the upper surfaces being a dull green. The glumes are similar to those of the common sedge and the two species are often confused. They can be told apart by looking at the ovary of a female flower. On the common sedge the ovary bears two stigmas at its summit; on the glaucous sedge there are three.

Flea sedge The third group of British sedges – those in which each plant carries just a single spike – numbers four species, of which only one, the flea sedge, is common. This species, which occurs throughout the country in damp grassland overlying chalk or limestone and in fens, is aptly named. The top, male, half of the spike is narrow; on the bottom, female, half the glume on each flower drops off early on and the fruit, which is upright at first, gradually spreads outwards and downwards, and for a time bears two outward-curving stigmas. At this stage the female flower looks exactly like a flea perched on the stem.



Above: Most British sedges have their male and female flowers borne on separate spikes. Above left are the male spikes of pendulous sedge (*Carex pendula*). These are 6-10cm (2½-4in) long and are borne at the top of the stem, one or two at a time. Below them are four or five female spikes (above right), which are much thinner and longer – up to 16cm (6½in) in length. The female spikes are upright at first but generally droop by maturity.

Below: Sand sedge (*Carex arenaria*) spreads by means of underground runners – rhizomes – which grow through the sand, sending up shoots every few inches.

CHAFFINCH AND BRAMBLING

The chaffinch, our commonest finch, has a breeding population in the millions. Its close relative, the brambling, visits our woodlands for the winter.

The chaffinch is the most widespread and numerous British finch, and one of the most numerous of all British and Irish birds, especially in winter when our resident chaffinches are augmented by extra millions of European birds. Estimates of our breeding population made during the last 40 years have ranged between four and seven million pairs. The species is ubiquitous throughout the British and Irish mainlands, but uncommon in the Hebridean Islands, the Orkneys and Shetland.

White wing bars The summer plumage of the male chaffinch is unmistakable: a deep wine-pink breast contrasts with a dove-grey crown and nape and a black forehead, a russet mantle and dark blackish-brown wings and tail. White feathers are visible at each side of the tail, even when it is tightly closed; but perhaps the most conspicuous recognition feature of all is the double white wing bar. The two bars are as clearly visible on the perched bird as in flight. The foremost white bar covers the 'shoulder' (the wrist in human terms) of the closed wing in a broad white patch; behind this, the greater coverts carry a more slender stripe.

These striking wing markings are also seen on the female, which is otherwise clad in a mixture of browns and beiges for camouflage. In winter, the male too is more sombre in

Above: Chaffinches usually raise only one brood each year, and begin their nesting activities in late April or early May. The nest is one of the most neatly constructed, and well concealed, of all our birds' nests. The basic structure is of moss, with a framework of grass and rootlets. The outside of the nest is usually ornamented with lichen or flakes of white bark taken from birch trees, if the nest happens to be in or near one of these.

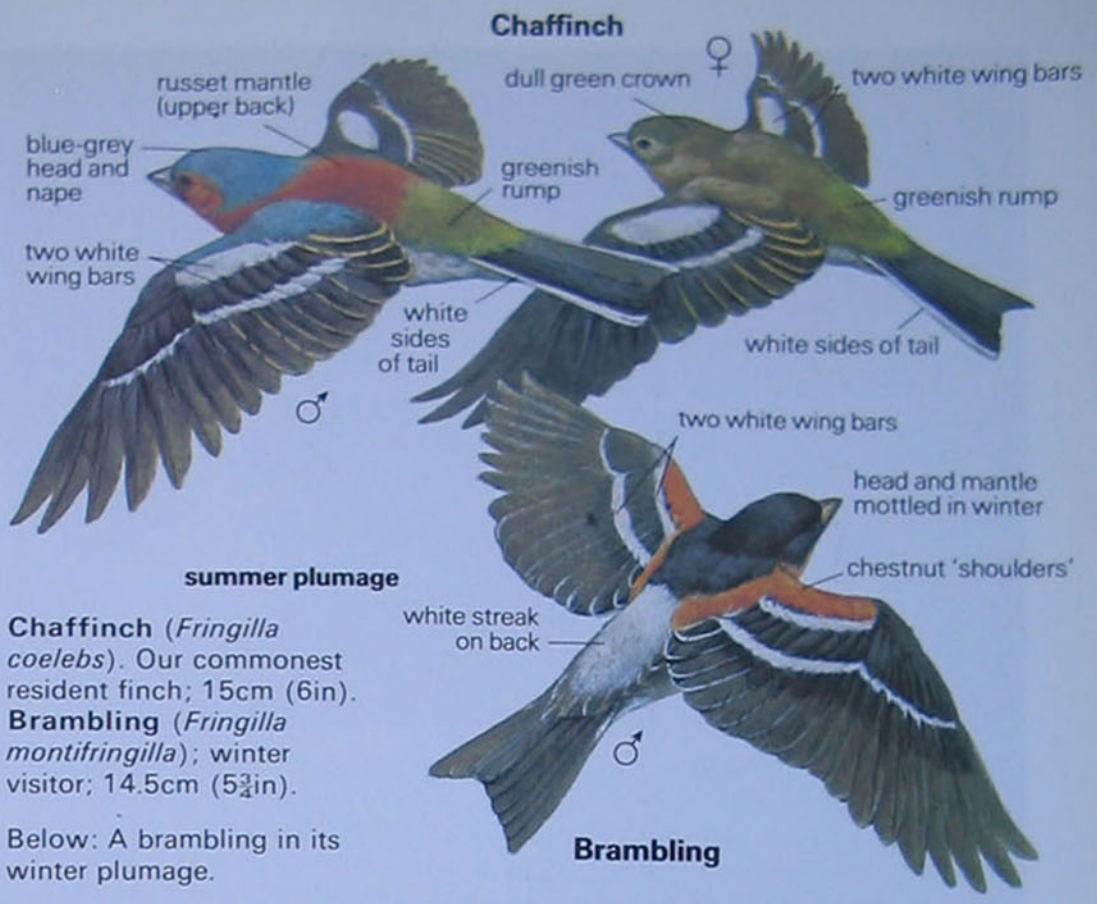
Right: The cup is lined with soft hair or feathers, and usually contains 4 or 5 eggs, but occasionally nests with as many as 8 are found. The eggs are whitish blue, marked with dark purplish-brown spots and squiggles.

plumage, when subtle camouflage among the stubble is more important than the bright colours of display. At all times of year, both sexes have a grass-green rump patch, which is particularly noticeable when you see the birds taking off.

Chaffinch song Chaffinches start to sing early in the year: from February onwards in the south (later in the north) their boisterous song can be heard in almost any part of the countryside. It consists of a long descending trill with a final swashbuckling flourish. One of the most intriguing questions of bird song is how such complicated and often beautifully melodious phrases are passed on from one generation to the next.

Recent research at Cambridge University has gone some way towards unravelling this mystery in the case of the chaffinch. The Cambridge experiments suggest that the basic framework of the song is inherited, for it is produced 'automatically' even by a young male chaffinch reared in total isolation. In the wild a young male, possessing these instinctive foundations of song, listens to his elders and gradually develops the quality, and the trills and flourishes, of his full song. In such a way, local 'dialects' develop: West Country chaffinches, for example, sound as different as their human counterparts do to a visitor from, say, London.

Woodland bird Chaffinches are essentially woodland birds, but they inhabit a wide range of different types of woodland. The densest populations are normally found in mature broadleaved woodland, especially oak with wide glades, but most other types of woodland (including the darkest and densest Norway spruce) support chaffinches, as do scrubland, farmland, parks and gardens. In remote areas in the north and west, it seems that even a clump of weatherbeaten trees or bushes is sufficient to encourage a chaffinch pair to take up residence. In winter, many forsake woodland and join other finches, sparrows and buntings on farmland, especially where plenty of cereal or weed seeds are available.



Chaffinch (*Fringilla coelebs*). Our commonest resident finch; 15cm (6in).
Brambling (*Fringilla montifringilla*); winter visitor; 14.5cm (5¾in).

Below: A brambling in its winter plumage.

Varied diet In summer the diet is very varied, not having such a high seed content as that of most finches. It includes small snails and worms, various fruits and seeds, and often aphids gathered high in the woodland canopy. For the first few days after the young have hatched, chaffinches feed their brood mostly on insects, and their beaks, relatively long-pointed and slender for finches, are suitable both for this and for the small seeds that they also tend to select. In winter, foraging is done more often on the ground than in the treetops, and seeds tend to predominate.

The brambling Bramblings breed from northern Scandinavia eastwards into Siberia. Their chief breeding habitats are birch woodland and the mixed woodland fringes of large expanses of coniferous forest. In winter they

migrate south to the Mediterranean and west to Britain and Ireland.

Like the chaffinch, the brambling has white wing bars: these are much less bold than those of the chaffinch, and are not always visible when the bird is on the ground, though they can be seen clearly when it is in flight. When flying, the brambling shows a more mottled upper surface than the chaffinch, with a conspicuous white patch on the rump, which is its best identification feature. It contrasts strongly with the green rump of the chaffinch.

On the ground in winter, the mottled plumage is good for camouflage, but a close view reveals the orange breast of both male and female, the all-brown or blackish-brown heads, and the orange-buff shoulder patch of the male, all of which help to separate the brambling from the chaffinch. As winter progresses into spring, the mottled blackish brown head and mantle of the male brambling become glossy black as the paler feather fringes wear away, and he comes into his breeding plumage, which we are only rarely lucky enough to see.

Above: A female chaffinch. At all times of year, in flight or on the ground, the common chaffinch call is 'pink, pink'—the basis of the Dutch name for the species, 'fink', and indeed the English word finch. This same call, more stridently produced, is used as an alarm, to warn, for example, of the approach of a jay or the presence of a roosting owl.

Left: A male chaffinch in the snow, towards the end of winter. In winter, his plumage is less vivid than in summer. After the autumn moult, most of the newly grown body feathers have broad buff fringes. As winter proceeds into spring, the fringes wear off, revealing the beauty of his plumage beneath—in time for the spring display. In this bird, the fringes are almost worn away, but still dull the full brilliance of the plumage.

The male's plumage is much more striking than his song, which is a metallic, poorly formed jumble of 'dwee' calls and chirrups. Bramblings have several flight calls—a low-pitched 'chuck-chuck-chuck' and, more characteristically, a hoarse 'zweek' and a metallic 'dwee' which rises in inflection as it ends.

An irregular visitor As a winter visitor, the brambling is irregular in the extreme. In most years there are a few bramblings scattered throughout Britain, but occasionally (and normally in years when there has been a very heavy crop of beech mast) numbers are much higher. The erratic nature of brambling migration is largely responsible for this. Instead of adopting a routine pattern of autumn and spring migrations to and from regularly used wintering areas, bramblings move to wherever their food is easily found.

This means that birds wintering in Britain one year may be found (say) in northern Italy or Yugoslavia the next. Most arriving migrants reach our east coast—often in company with Continental chaffinches—in October and early November; in years of low numbers they may not even reach the West Country. The return journey usually starts during March.

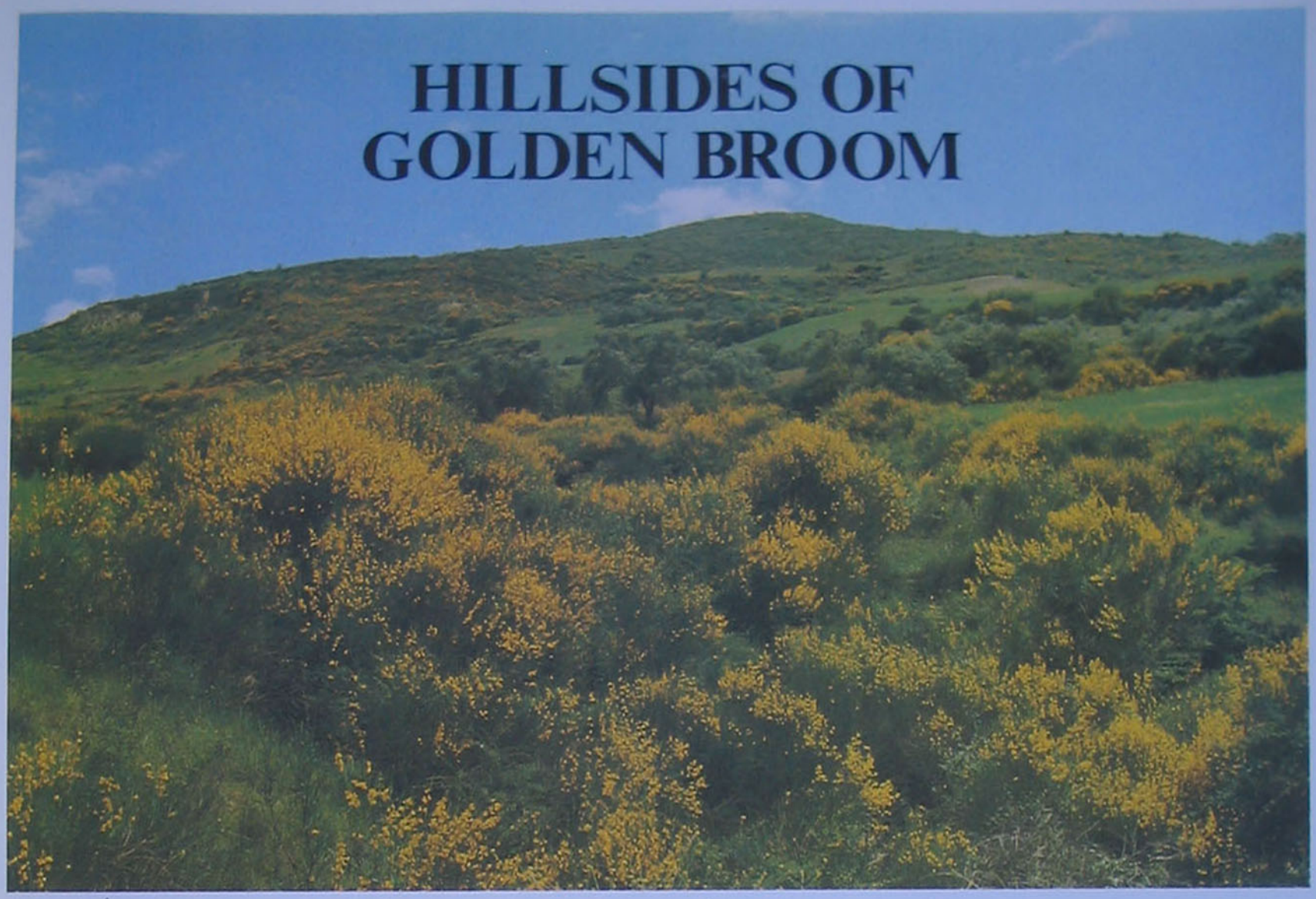
Beech mast is an important component of the winter diet, which also includes a few late berries and many seeds. Bramblings are usually seen foraging on the ground under a large area of mature, widely spaced and heavily cropping beeches; otherwise they can be found with other finches and buntings in weed-grown fields, stubbles, and around feeding places for farm livestock, where seeds have dropped from hay and straw.

The only positive British breeding record of bramblings was in 1920 in northern Scotland, but recently there have been several instances indicative of breeding elsewhere in Britain. These suggest that the brambling may follow two other Scandinavian birds, the fieldfare and the redwing, and establish regular breeding colonies.

Which are our commonest breeding birds?

The most reliable guide at the moment is the B.T.O.'s survey of 1968-72. Although this is now over a decade old, the populations of the birds referred to here happen to be generally stable ones, which means that the overall picture still applies today. Another point to remember is that populations of some of the species mentioned here rise in winter. The highest breeding population of all is that of the wren, estimated at 10 million pairs or more. After this the picture is a little confusing, for estimates can only be rough and include guesswork, however well informed. The blackbird probably takes second place, with a firm estimate of seven million pairs. However, the chaffinch population is estimated at between four and seven million pairs, as is that of the starling. Coming in the middle of this range are the less vague figures of around five million pairs each of robins, dunnocks and blue tits. The house sparrow's possible range of three and a half to seven million pairs may place it among the highest populations.

HILLSIDES OF GOLDEN BROOM



From late spring into summer whole hillsides can become a vibrant golden-yellow as one of our most attractive shrubs, broom, comes into flower.

Broom is widely distributed throughout western Europe, its range extending from Scandinavia south to Spain, Madeira and the Canary Islands. Broom is also native to the British Isles and is fairly common here, although it is excluded from the far north of Britain. It favours open sites but tolerates some shade and can be found growing in woodland, provided the trees do not cut out too much light. Broom grows best on a sandy soil and it is completely absent from basic soils, such as those found over chalk or limestone.

Gorse-like shrub Broom is a deciduous shrub, usually growing up to 2m (6½ft) high. It is a member of the pea family and closely related to gorse, from which it is distinguished by its lack of spines.

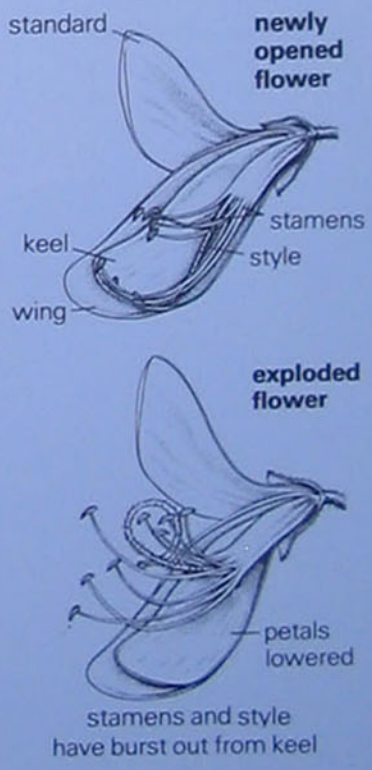
The leaves of broom are small—no more than 10mm long—and may be either undivided or split into three leaflets. Under adverse conditions the leaves are quick to shrivel and fall off; indeed, a broom plant is well able to survive without any leaves because its hairless, angled stems are green and capable of photosynthesising. Losing leaves in this way is one of this plant's adaptations to drought—broom is abundant in the Mediterranean region and the areas bordering the Sahara, where the summers are very long and hot. For much of the year, therefore, the broom plants in these parts are completely leafless since leaves, with their large surfaces, lose water much more quickly than do the thin stems. Then, following the winter rains, the plants produce a flush of leafy flowering shoots.

Pea-like flowers The golden-yellow flowers appear towards the tips of the current year's growth during May and June. Each is around 2cm (¾in) long and carried in the angle between the main stem and a leaf.

Like other British members of the pea family, each broom flower has a large upper petal called the standard, flanked by two more petals, the wings, partly enclosing the lowermost pair of petals, which are joined along their edges to form a structure called the keel. Inside the keel are the style and the stamens, the latter being joined together at the base to form a tube—the stamen-tube.

Pollination of this species is a lively affair, involving an unusual explosive mechanism. As the flower matures, tension develops between the keel, the stamen-tube and the style because each grows at a different rate. When a bee lands on the keel, the two keel petals break

Broom (*Cytisus scoparius*). Native deciduous shrub, widespread in the British Isles, preferring open sites. Height to 2m (6½ft).



Above: Cut-away of a broom flower showing the stamens and style first held under tension and then released after the visit of a pollinating insect.

Above: The typically pea-like flowers of broom. Notice how some flowers have been triggered by visiting pollinating insects, while others are still closed and under tension.

Opposite page: The remarkable prostrate broom (*Cytisus scoparius* subspecies *maritimus*), found along the exposed coasts of south-west England, Wales and Ireland. These plants were photographed on the cliffs of Dyfed.

Below: Broom pods in various stages of development. When fully ripe they will crack open violently and throw out their seeds.

apart suddenly, releasing the tension and causing the stamens and style to hit the body of the insect sharply. The flower becomes pollinated with any pollen already on the bee's body and the bee is dusted with a fresh supply. Despite being attracted by the bright colour and scent of broom flowers, the bees are not rewarded with any nectar. Still, they continue to visit the broom flowers, collecting and distributing pollen.

Flowers that have been triggered by a bee's visit are clearly noticeable since the lower pair of petals–the keel–hangs down and exposes the coiled style. Such 'exploded' flowers are rarely visited again by bees.

Explosive seed dispersal It is surprising that broom does not have a reputation for violence since not only its pollinating stage but also its method of seed dispersal uses an explosive mechanism.

Like so many species of the pea family, broom has elongated fruits called pods, a mature broom pod being between 2.5cm (1in) and 4cm (1½in) long and flattened, with black or brown hairs along the edges. When ripe, each pod splits open with a loud 'crack!', the two halves twisting violently apart and hurling the small pea-like seeds away.

Uses past and present The medicinal properties of broom have long been appreciated and an infusion of the flowering branches used to be taken as a tonic and a diuretic. Some people still drink broom tea, and broom wine is popular among amateur wine-makers.

Broom was also widely used in the manufacture of besoms and brushes, though whether the plant gave its name to the implement broom or *vice versa* is not clear.

Today, broom is widely planted to stabilise new motorway embankments because it produces a shallow mat of fibrous roots that bind together loose sandy soil and stones, and deeper water-seeking roots that give the plant a firm anchor.

Garden escapes The British species of broom is commonly grown in gardens, which is a considerable tribute to this handsome plant, bearing in mind the number of garden plants that were imported from abroad, to be planted in preference to those native to Britain. Garden brooms are, however, most often cultivated varieties with orange, red, pink or even white flowers.

Other species and hybrids of broom have been introduced to British gardens, several of which have become established in the wild, especially in southern Britain. One in particular, the Spanish broom, has become widely naturalised in southern England, where it is most frequently seen growing on railway embankments and the open parts of London's underground system. The flowers of the Spanish broom are larger than those of our native species–up to 2.5cm (1in) across.

Maritime subspecies On parts of the British coast you may find a highly unusual form of broom growing only a few centimetres tall. These maritime plants also differ from the normal form of broom in their leaves and young twigs, which are covered with silky, adpressed hairs (adpressed means that the hairs lie flat against the leaf or twig).

Stunted, distorted growth is a common feature of many trees and shrubs growing close to the sea. It is the result of constant buffeting by salt-laden winds and it can be easily demonstrated that, when such a plant is moved to a protected site inland, it reverts to its normal, more upright habit of growth. However, this is not the case with broom: a plant or seed of the maritime form retains the maritime features, even when grown inland. The differences between the inland and maritime forms are, therefore fundamental and determined by the plant's genetics. But the two forms are not quite distinct enough to be regarded as two separate species, so botanists usually treat the maritime form as being a subspecies of the inland plant.

ROCKY SEA-BED COMMUNITIES

On the rocky sea-bed the plants and animals growing at any one location are determined by a complex framework of environmental conditions in which the penetration of light, strength of wave action and velocity of tidal streams are all-important.

Below: *Tubularia* hydroids growing in a 'turf' of bryozoans. They can survive at depths where there is not enough sunlight for algae to live.

Until about 20 years ago, the rocky sea-bed around the British Isles was largely a mystery, but in the past 10 years or so scientists and naturalists have used improved diving techniques to observe, sample and photograph this colourful and fascinating world.

The amount of light penetrating to the sea-bed is one of the most vital factors determining the type and variety of life found there, but other factors, too, are important in influencing the distribution of species. One such factor is depth, and another is the strength of wave action (which decreases with increasing depth) and its effects on food supply, destruction of attached (sessile) species, dislodgement of mobile predators and the settlement of silt.

Food and feeding Animals fixed to the rock of the sea-bed have one major source of food: the organic material and plankton suspended in the water column. Such animals as hydroids, sea fans and bryozoans utilise this food supply in a passive manner by waiting for food to pass by in the water currents. The food is caught by minute anemone-like polyps or similar structures crowded along the branches. This might seem rather hit-or-miss,

but many species are highly adapted, having a flattened, fan-like structure which faces into the prevailing water currents to 'filter' the food. Other bottom-living species actively pump water through their filtration system; they include the fan worms and sea squirts.

Many species feed on the suspended material once it has settled to the bottom; they are the deposit feeders and include some worms, crustaceans, snails and bivalve molluscs. The most conspicuous of these is the black sea cucumber *Holothuria forskali*, which is over 20cm (8in) long and roams the sea-bed like an underwater vacuum cleaner, collecting silt and the organic material associated with it. A few species graze algae and animals from the rock, these including sea urchins and some molluscs. Others, such as the crabs, sea slugs, starfishes and fishes are active predators, often highly selective of their prey. Many species of crabs, lobsters and starfishes are also carrion eaters.

Waves and tidal streams Widely different animal communities develop on different areas of sea-bed under the influence of varying degrees of exposure to wave action and tidal streams.

Wave action can be extremely violent. A Force 8 gale can set up violent wave turbulence to a depth of 20m (66ft) near the coast, resulting in waves moving along the sea-bed at speeds of up to 30m (100ft) per second. However, the reduction of wave action with increasing depth means that, under the same Force 8 gale, water movement at a depth of 80m (270ft) is barely perceptible. This back and forth water motion can be highly destructive to erect sessile species since the constant movement causes tissue fatigue and tearing near the base, or else tears the whole plant or animal away from the rock. Secondary effects may also include the abrasion of rocks and organisms by the movement of boulders, stones, gravel and sand during storms.

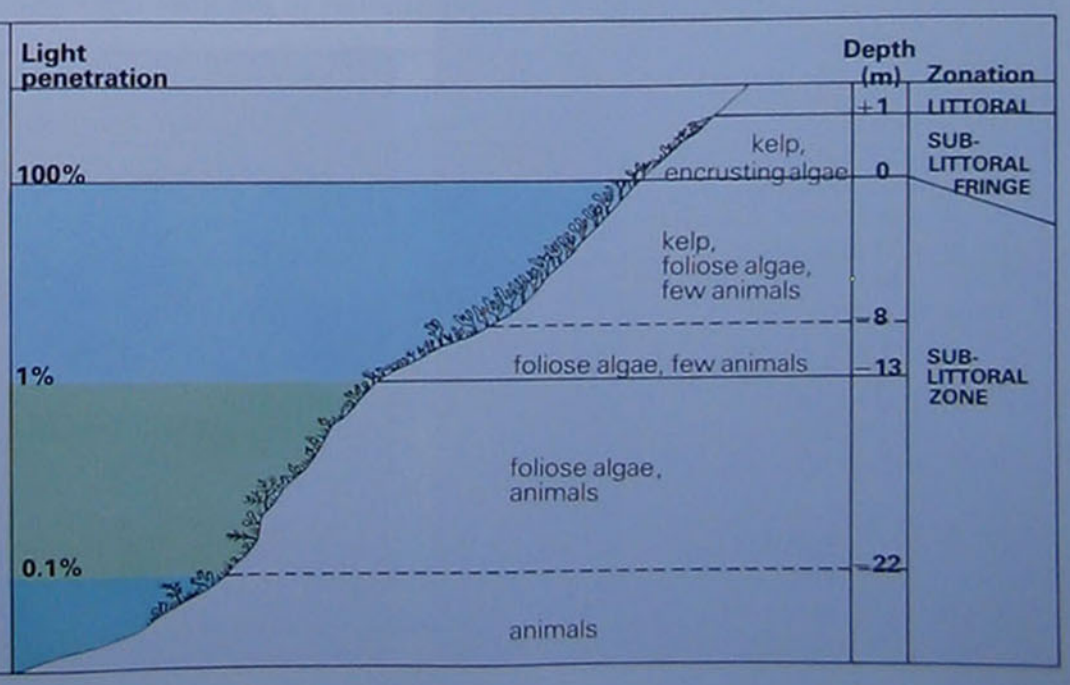
The strength of tidal streams near the coast ranges from almost nothing to up to 10 knots

Above: One of the larger vertebrates found on the rocky sea-bed—the lumpsucker fish. Here the fish is guarding its nest and eggs.

Right: *Antedon bifida* feather stars—these crinoids often dominate large areas of the sea-bed. They are suspension feeders, the food being caught along the arms and transferred to the mouth at the central disc. The distribution of plants and animals on the rocky sea-bed is determined by the conditions of wave exposure, tidal flow, topography, scouring and other factors, but on any one patch of sea-bed, different communities develop according to chance historical events.

Sub-tidal communities

Sea water, together with particles of sediment suspended in the water, absorbs, scatters and reflects light so that the amount reaching the sea-bed is reduced rapidly with increasing depth. In shallow well-lit areas seaweeds (algae) dominate the sea-bed, particularly the brown and red algae. Kelp forms forests in shallow waters, the depths at which it lives ranging from less than 1m (3ft) below water level, where turbid waters predominate, to 25m (80ft) where the water is very clear. Kelps can only grow where more than 1% of surface illumination is usually present, but smaller foliose algae thrive where light intensity is less than this. In the depths where light is too dim for algae, such animals as sea firs (hydroids), sponges, sea anemones, sea mats (bryozoans) and sea squirts dominate the rock, together with crabs, lobsters, sea urchins, starfishes and fishes.



Above: A community of the orange sea squirt *Dendrodoa grossularia*, with the white sponge *Clathrina coriacea*. They are characteristic of shallow wave surge gullies. A yellow sponge and a purse sponge can also be seen. Both wave action and tidal streams bring food for suspension feeders and prevent smothering by silt and deoxygenation. These same forces, however, can also be highly destructive.

(11½ miles per hour) at the surface (about 15m/50ft per second near the sea-bed), depending on geographical location and coastal topography. Again, such forces can be highly destructive. However, both wave action and tidal streams bring food for suspension feeders and prevent smothering by silt and deoxygenation.

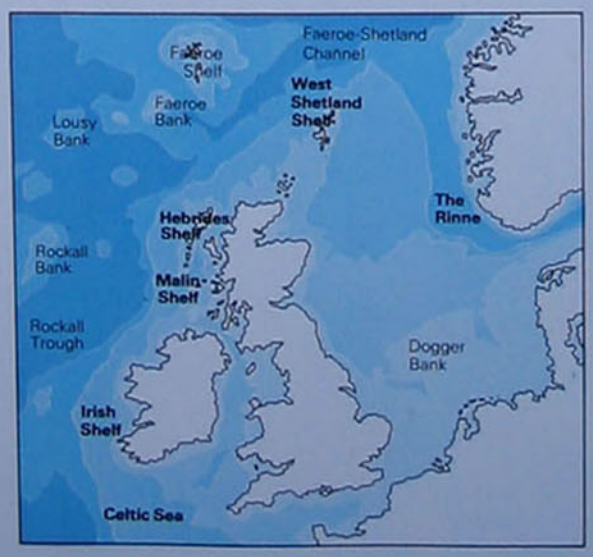
Distribution of communities The different susceptibilities and needs of the plant and animal species colonizing the rocky sea-bed, in relation to the strength of water movement and its effects, lead to the presence of widely different communities in different regimes of wave and tidal stream exposure.

In shallow areas exposed to violent wave action, for instance, a particularly distinctive community develops. Here, the sea squirt *Dendrodoa grossularia* and the sponge *Clathrina coriacea* thrive together, accompanied by a small variety of other sponge, hydroid and sea anemone species that are consistently found in this type of habitat. On coasts facing the most severe exposure to the Atlantic the forest of large kelp plants normally present in shallow water is reduced to a few scattered small plants, while the main species which settle and dominate the rock are fast-growing, short-lived algae and animals, such as some of the foliose algae and sponges, hydroids and barnacles. In the deeper, animal-dominated areas, rocks are often characterised by a low turf of hydroids and bryozoans, with erect species such as the branching sponges and sea fans restricted to gullies and potholes sheltered from the full force of wave oscillation.

Strong tidal flow encourages a different type of community from that able to survive strong wave action. Such areas as the narrowest parts of the Menai Straits, Ramsey Sound and Strangford Lough Narrows are populated by communities dominated by the sponge *Halichondria panicea* and the hydroid *Tubularia indivisa*. Again, there are other species usually associated with this distinctive community, forming a restricted range of organisms able to withstand such severe en-

Continental Shelf

The edge of the Continental Shelf is located to the west of Britain, where the water depth is in excess of 200m (656ft). Most of the seas immediately surrounding the coast of Britain, including the entire North Sea, are relatively shallow (less than 200m/656ft deep).



Depth (m)
0–50
50–100
100–200
200–1000
1000+

vironmental conditions. But distinctive communities are also found at the other end of the spectrum, in the extreme shelter of sea lochs. These communities are characterised by large sea squirts such as *Ciona intestinalis*, species of *Ascidiella* and *Ascidia mentula* and by delicate fan worms including *Sabella penicillus* and *Bispira volutacornis*. In such extreme shelter there is often no kelp forest, the shallow water rocks instead being dominated by a green, cottonwool-like cover of filamentous algae and by the cord weed *Chorda filum*. Where kelp plants do occur, they are of the species *Laminaria saccharina*, which has short stipes and long crinkled fronds.

Geographical distribution There is a distinctive geographical element to the composition of sea-bed communities. The British Isles lie at the meeting point of three major biogeographical provinces: the Arctic-Boreal with its centre well to the north of the British Isles; the Mediterranean-Boreal which extends near the north of Scotland; and the Mediterranean-Atlantic which extends northwards to the English Channel and the western approaches.

In the south-west of Britain, communities dominated or characterised by a wide range of sponges, hydroids, anemones and their relatives, and erect bryozoans are present. Many of these species are found in abundance only in the south-west and, by chance, are some of the most colourful and spectacular forms of marine life. They include such species as the red sea fingers (*Alcyonium glomeratum*) and the sea fan (*Eunicella verrucosa*), yellow zoanthid anemones (*Parazoanthus axinellae*), the hydroid *Gymnangium montagui* and such cup corals as the yellow *Leptosammia pruvoti*. Many seaweed species are also restricted to the south-west and some, such as the kelp *Laminaria ochroleuca*, can dominate the sea-bed. The distribution of some of these species appears to be closely associated with the proximity of oceanic water and they extend all round the western coasts of the British Isles.

To the far north the picture is different. There are not as many species; many of the southern ones are lost and only a few northern species appear to replace them. These few northern species, which are not found or are only rarely encountered in the south, sometimes dominate the sea-bed. An outstandingly successful example is the horse mussel *Modiolus modiolus*. This large mussel colonizes both rock and sediment and provides a habitat for a wide range of other species and *Modiolus* communities sampled from widely different areas are remarkably similar. Some of the most exciting discoveries in recent years have been made in the sea lochs of Scotland, where communities very similar to those of Norwegian fjords have been found. These

Above: Polyps of the yellow sea anemone (*Parazoanthus axinellae*) – a species rarely recorded and, until recently, thought to be restricted in distribution to south-west England and Wales. In 1982 it was recorded from the Hebrides.

Below: Waving fronds of a kelp forest. The species is *Laminaria hyperborea*; it is characteristic of temperate waters and forms forests in shallow water.

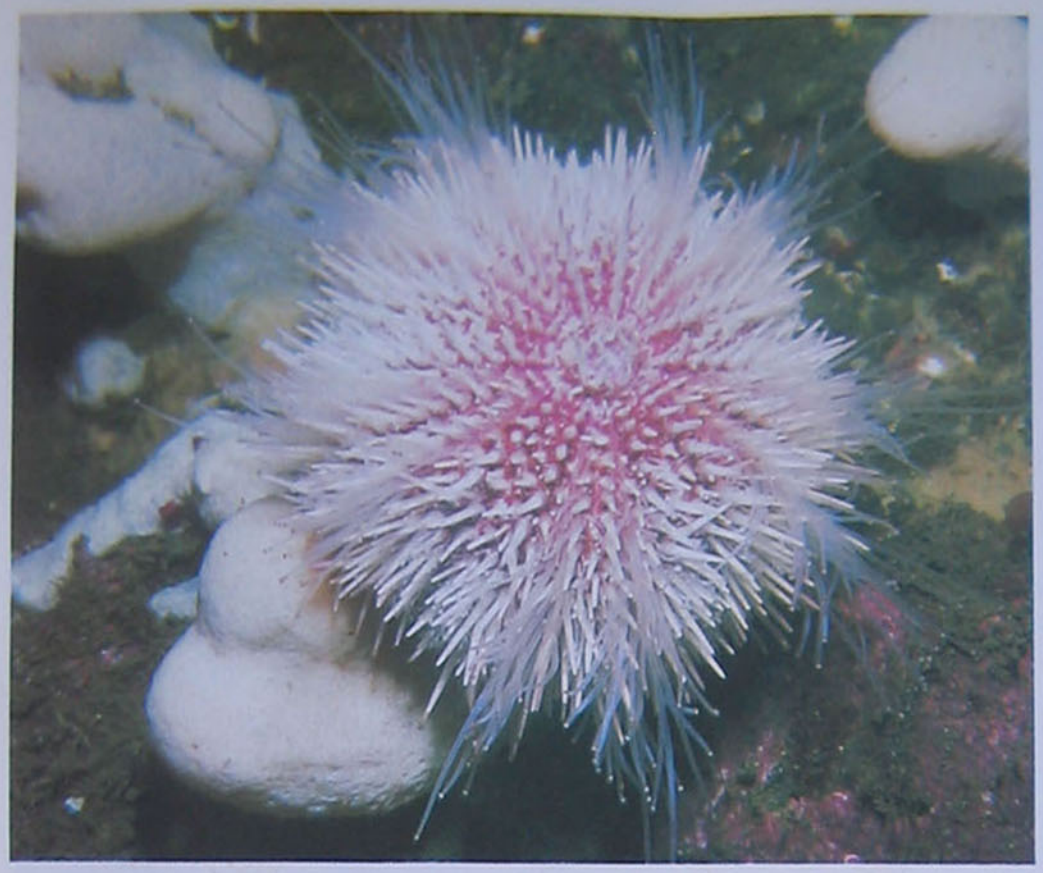
Below: A close-up of a rich rock community off the island of Lundy. The animals visible here include erect bryozoans, the sponge *Leucosolenia botryoides*, the Devonshire cup coral *Caryophyllia smithii*, and the sea slug *Greilada elegans*.

communities are characterised by such species as the sea anemone *Protanthea simplex* and by the brachiopods (lamp shells) *Crania anomala* and *Terebratulina retusa*. Northern species of seaweeds also take over as dominant or characteristic species on the coasts of Scotland; one abundant species is *Odonthalia dentata*.

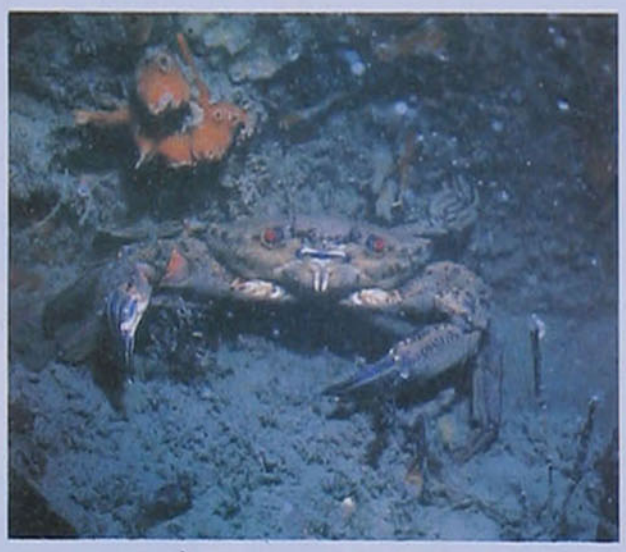
There are other features of particular areas which give them a strong regional characteristic. One such is the abundant growth of brown dead men's fingers (*Alcyonium digitatum*) and plumose anemones (*Metridium senile*) in rocky areas of the north-east coast. Others are the communities associated with limestone where piddocks bore into the rock, thus providing holes that shelter a characteristic fauna, and certain areas of the upper Bristol Channel where the effects of a stressful water quality and suspended sand lead to the development of communities dominated by worms of the genus *Sabellaria*, which construct their dwelling tubes from sand.

Stability and change Man has influenced hardly at all the plants and animals that colonize the rocky sea-bed and the communities present there are some of the last natural ones existing in our islands. These communities appear reasonably similar when viewed from year to year, although considerable seasonal changes occur in a few species.

Some species are extremely long-lived; the sea fan, for instance, grows at a rate of only about 1cm ($\frac{3}{8}$in) a year, but reaches a height of 40cm (16in). Other species have a very short life but colonize, grow and die in a year, so providing a similar appearance on the sea-bed in a particular area at the same time each year. Some species, on the other hand, show variable recruitment and may dominate an area for a few years then almost disappear.



Above: The sea urchin *Echinus esculentus* exerts a major influence on the ecology of underwater rocky areas. It is present in large numbers in areas of south-west England, the Isle of Man, Scotland including the Shetland Isles, western and northern Ireland and the north-east coast of England. In places its density exceeds one per square metre. In such numbers the sea urchin can effectively keep the rocks clear of erect growth, with the exception of a small range of fast-growing resistant species or species with defensive equipment. However, it does not graze to bare rock in shallow areas where pink encrusting calcareous algae cover the rocks—the algae appear to be unaffected by the grazing urchins. In areas where the urchin density is less than ten per square metre, it probably has a beneficial effect on the marine communities by creating bare rock which can be colonized by a fresh community.



Above right: The velvet swimming crab (*Liocarcinus puber*) is a predator and carrion eater on sub-tidal rocky sea-beds.

Right: Dense foliose algae dominating sandy rock in well-lit waters.

CHITONS: ARMOUR PLATED MOLLUSCS

If you explore the seashore where there are plenty of boulders, rock pools and crevices, you may well find a few chitons. These are small armour-plated molluscs that graze algae from the rocks, retreating into crevices or under stones at low water.

Above: Some specimens of *Acanthochitona crinitus*, like this one, are unusual in being brightly coloured: chitons of almost all species are usually dark or dull coloured. Although they are not prominently visible here, *Acanthochitona* has many tufts of bristles along the flattened outer fringe of its soft body. This fringe is the external part of the mantle, and is usually called the girdle. The plates of the shell overlap with one another to allow flexibility.

There are approximately 600 species of chitons worldwide, of which 12 are found in British waters. Most British chitons (pronounced kite-ons) are fairly small – less than 2cm ($\frac{3}{4}$in) long. Although not uncommon on British shores, they are easily overlooked, particularly in comparison with their larger and more obvious molluscan relatives such as the winkles, whelks, mussels and cockles.

Chitons make up the class Polyplacophora, one of the six classes of molluscs found in our coastal waters: the major classes are the gastropods, bivalves and cephalopods, while the minor groups (of less ecological importance) include the chitons and tusk shells, together with a sixth group, the aplacophorans, which are rarely seen in shallow waters.

Coats of mail The ecological habitat occupied by chitons is typically one of turbulent water caused by breaking waves, and they spend most of their life pressed closely to rocks on the seashore or submerged in the sea, grazing on small seaweeds. As an adaptation to this way of life, their bodies are flattened, allowing any waves to flow over without detaching them. The bottom of the chiton consists mostly of a large sucker-like foot similar to that of a snail. A further adaptation to their way of life is the flexible shell. This is divided into eight overlapping plates, giving chitons their common name of coat-of-mail shells.

The eight shell plates, made of calcium carbonate, lie embedded in fleshy tissue called the mantle along the back of the chiton; round the outer edge of the body there is a broad girdle (the peripheral area of the mantle), which in some cases is strengthened by needle-like features known as spicules. The head does not protrude at the front, but when viewed from underneath it can be seen to be separated from the large foot by a groove. The foot can exert a very strong suction on to the rock, and the body of the chiton is flexible enough to conform to uneven surfaces. If the chiton is detached from the rock, it may roll up into a ball like the pill bug woodlouse, or an armadillo, to protect itself.

Grazing equipment Chitons feed in a man-

ner similar to that of garden snails, scraping vegetation (in this case from the rock) with the radula, a ribbon-like structure bearing the teeth, which are arranged in rows of 17 teeth per row. These teeth are hardened by a high iron content to prevent them from wearing out before new rows of teeth are pushed forward as the radula is extruded during growth. The plant food is covered with mucus before being swallowed, and between scrapes the chiton protrudes a tasting organ from its mouth to test the palatability of the next mouthful.

Inside the mantle cavity On the underside of the chiton, a groove runs in a deep U-shape round the sides and rear of the foot, separating it from the girdle which lies between the foot and the shell. This groove, the mantle cavity, contains the gills, which hang down and interlock so as to form a curtain. This effectively divides the groove into inner and outer chambers.

The gills are covered in hair-like structures called cilia, which beat in rhythm and drive water into the external chamber of the mantle cavity at any point where the foot is lifted from the rock surface. Thus a water current flows in across the gills and into the inner chamber. The gills extract oxygen from the water as it passes; the water then flows down the inner chamber alongside the foot, to exit at the back of the animal.

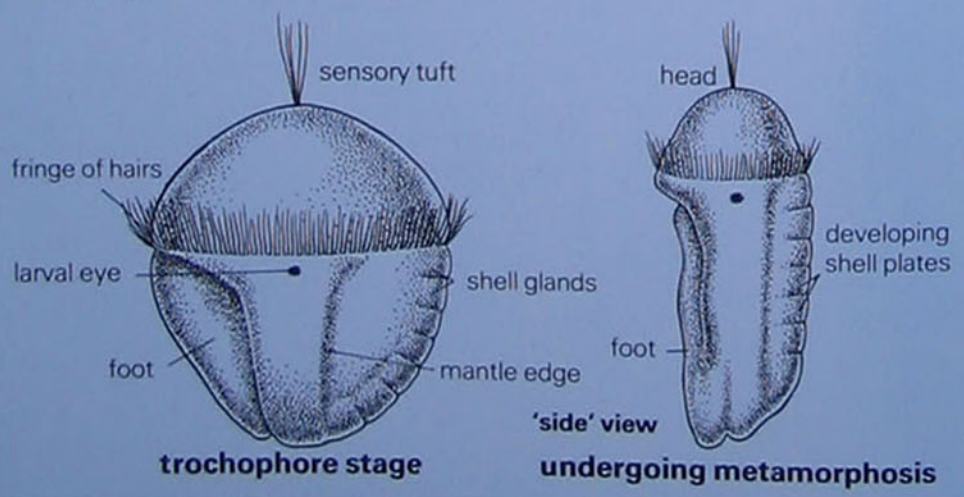
Most other molluscs have a single pair of gills in the mantle cavity, but because chitons are so flat the gills are subdivided into small separate units along the mantle cavity, and the cavity is even extended forwards on either side of the foot to provide room for them. The gills increase in number as the chiton grows, but not necessarily in equal numbers on each side. Some species have up to 80 gills when fully open. In spite of the large number of gills, the total area of respiratory surface is only equivalent to that of the two large gills found in other molluscs.

How chitons breed In most species, the sexes are separate, and the eggs and sperm pass out in the exhalant water current. Fertilisation takes place externally in the sea, and the fertilised egg develops into a larva called a trochophore–similar to the larvae of some bristle worms and of other molluscs such as limpets. The trochophore swims in the sea by means of cilia (tiny hairs) for about six hours but does not feed–surviving on the yolk reserves supplied by the egg. The larva then settles on to the sea bottom, often being attracted to a region of rock occupied by the favourite food of the species. The first six shell plates appear as the larva elongates to take up the characteristic chiton shape, and then a final shell plate is added at each end to bring the complement to eight.

Above: *Acanthochitona communis,* another bristly chiton. When exposed at low tide, chitons remain motionless.

Below: *Tonicella rubra,* also found intertidally, is less common than *Acanthochitona*.

Development of a chiton larva



Chitons in British waters There are two families of chitons in the coastal waters of Britain and Ireland, only one of which is found in the intertidal region. The intertidal chitons–of which *Lepidochitona cinereus* is the commonest example–evolved at a later stage and represent a more advanced degree of adaptation to the intertidal habitat. They have more flexible bodies and shells, and they also have far more numerous gills. This family also possesses a further advantage in hav-

Five molluscan classes

The grey topshell is a **gastropod**: it is a plant-grazing animal, but some gastropods (such as whelks) are carnivores. All land molluscs—slugs and snails—are gastropods.
The queen scallop is a **bivalve**, its shell being divided into two opposite halves. The bivalves are plankton feeders.
The common cuttlefish is a **cephalopod**, a swimming predator feeding on fishes and other animals.
Minor molluscan groups include the **chitons** and **tusk shells**. Chitons cling to the rock with a large sucker-like foot; their bodies are flat, enabling them to stay firmly in place amid waves.
Tusk shells burrow into sand or mud, with the shell protruding like a 'chimney' and acting as an intake for water. They feed on micro-organisms in the sand or mud, which they seize one by one with tiny tentacles.

POLYPLACOPHORA
(Chitons)

Chiton
Lepidopleurus asellus

BIVALVIA
(Bivalve molluscs)

Queen scallop
Chlamys opercularis

GASTROPODA
(Snails and slugs)

Grey topshell
Gibbula cineraria

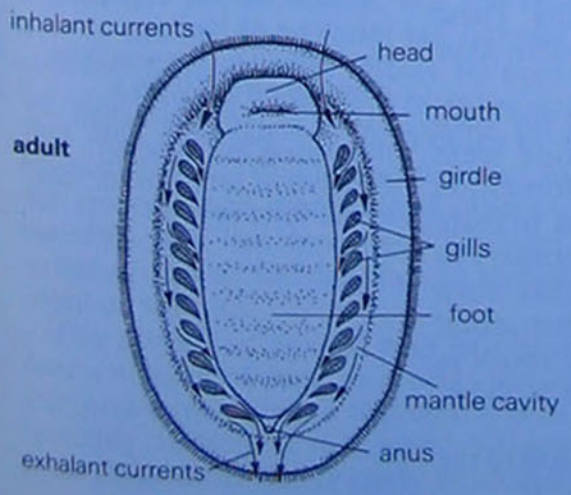
SCAPHOPODA
(Tusk shells)

Tusk shell
Dentalium entalis

CEPHALOPODA
(Cuttlefishes, squids and octopuses)

Common cuttlefish
Sepia officinalis

Underside of a chiton



Above: Our commonest chiton is *Lepidochitona cinereus*. When covered by the tide it grazes on the upper surface of the rock.

Left: On the underside of a chiton you can see the numerous gills inside the groove or mantle cavity. The gills divide the cavity effectively into inner and outer chambers. Water enters the outer chamber and passes across the gills, along the groove and out at the rear.

ing more highly developed senses: *Lepidochitona cinereus*, for example, has nearly 2000 sense organs per square millimetre of its shell surface.

These organs are sensitive to environmental features such as light and humidity, and the chitons show complex behaviour patterns in response to the information they provide. The animals move upwards to the rock surfaces to graze when these are submerged at high tide, and downwards towards the darkness and dampness of crevices or the undersides of boulders when the tide is out.

The bristly chiton *Acanthochitona crinitus* is also a member of the intertidal family. It has many small tufts of bristles on its girdle. Another member, *Tonicella rubra*, is always found on rocks encrusted with red coralline algae, its favourite food. It is well camouflaged against this background, for it is a rich red, flecked with white. This makes it one of our most attractive chitons.

The second chiton family occurring on our coasts is restricted to the deeper waters below the low tide mark. With less flexible bodies and shells, these chitons cannot compete in the changeable intertidal habitat. The most common example is *Lepidopleurus asellus*, which is abundant at a depth of about 50m (25 fathoms). It is often found on the shells of other molluscs, feeding by scraping up the black film of micro-organisms such as bacteria which cover the shells.

MAMMAL COURTSHIP: LOOKING FOR A MATE

Courtship among mammals is often an elaborate ritual which minimises aggression and gives normally solitary species a chance to find a mate. For all animals it is an opportunity to identify the condition and ability of potential partners and to perpetuate their genes by reproduction.

Above: A fallow deer buck calling during the rut in October, and a hind. Some mammal species are solitary throughout the year, apart from a brief period when they meet to mate. Others, such as the fallow deer, are gregarious and, with the exception of the adult males, spend much time in herds. Male mammals put most of their reproductive energies into mating, with selection favouring those which are good at finding and competing for females. Females, on the other hand, put most of their reproductive energies into parental effort, with a period of lactation when the young are directly dependent on them for food in the form of milk.

The long winter nights of the British countryside are often interrupted by high-pitched screams that can travel for a mile or more, sending chills down the spine of most people. However, these cries, made by vixen foxes, carry a particular message to other foxes: they herald the vixen's presence, warning others to keep away and informing dog foxes that a potential mate is nearby. They are a noisy affirmation that winter is the foxes' courting season.

The right species, the right time For invertebrates, such as insects, and lower vertebrates, such as fishes and birds, courtship is a means of establishing the species of the partner: each individual performs a series of actions which, unless they obtain the correct response, prevent the occurrence of what would be a biologically useless mating. These animals, the peacock for example, often have elaborate visual displays.

In mammals, however, the need for such displays is lessened, perhaps because scent provides much of the necessary information about the species, sex and readiness to mate of the partner. Courtship, as a preliminary to mating, appears instead to ensure that when the female has reached the point in her sexual cycle when mating is most likely to result in pregnancy, a sexually excited male is there, ready to pair with her.

Since there is usually only one period of the

year which is best suited to the birth and growth of the young of many species, it is important that mating occurs at the right time. Many British mammals are solitary for most of the year, often occupying a territory which they may mark with scent to warn off intruders, so reducing competition for food. Scent marking probably also reassures the owner that it is on home ground. When food is scarce and widely dispersed, individuals may themselves be at low densities, ranging over large areas. This reduces competition for food, but it makes it more difficult for an animal to find a potential mate. To overcome this, mammals may alter their behaviour during the mating period, ranging more widely or using special scents or calls, such as that of the vixen fox referred to earlier.

The female usually becomes attractive to the male considerably earlier than the period when she is sexually receptive to mating. This allows her to evaluate a number of courting males to find the best mate for her–the strongest, or the most compatible, or the best able to obtain food during the difficult time after the birth, or a combination of all these factors.

The reproductive efforts of the female go mainly into bearing and then feeding and caring for the young, while those of the male go into finding and mating with the female. Males can have many more young during their lifetime than females since they can mate with several females, whereas once a female has been successfully mated she cannot mate again during pregnancy and lactation. These different levels of investment in the young, and the different reproductive potentials, are fundamental differences between the sexes, and are probably responsible for the behaviour changes they show during courtship. The selection of mates which results from competition between courting males may also be a reason for the evolution of a period when the female is attractive, but not receptive.

Early stages Initially, at least, courtship is usually a one-sided affair, with the male making all the advances and being evaded or repulsed by the female. The pursuit of the female by the male is thus a common part of courtship behaviour. In the hedgehog, for example, the male follows the female, attempting to sniff at her genital region, but she repulses him by butting and biting. He retreats, but continually renews his efforts to approach her, snorting and hissing in a threatening way. This may continue for 20 minutes or more before the female runs a short distance, lowers her spines (since these would otherwise be harmful), and lies down with hindlegs outstretched behind for the male to mount and copulate with her.

This process of pursuit may be prolonged over a number of days, as is often the case in the carnivores. When a female fox is in heat (sexually attractive), her smell attracts the male long before she is ready to accept him.

He may therefore attend the female for a long period, and since he is strongly inhibited from biting her at the time, he does not retaliate in the initial stages when she repulses him. He simply follows her around and tries to sniff her genital region. As she comes more fully in to heat which, presumably, he detects by smell, she ceases to repulse him and may even invite copulation by standing in front of him in the mating posture.

Elaborate affairs Courtship among carnivores, though prolonged, is not a sophisticated affair as it is with some other mammals, such as squirrels. The male red squirrel may follow the female, or may actively chase her. The female accelerates if the male approaches too rapidly, but if he shows signs of giving up she may pause to wait for him, or may even move back towards him. As he approaches, the male makes a special call which closely resembles the cry of the young when trying to maintain contact. This probably helps to inhibit the female's aggressive tendencies–a necessary prerequisite for close approach by

Above: Red deer fighting. The mating success of a stag depends on its fighting ability, the strongest animals having the largest harems and hence the opportunity to sire the largest number of offspring. Fighting, however, can be costly: an individual stag may damage his antlers, break a leg or become blinded by an antler point.

Below: A rabbit scent-marking–releasing pheromones from its chin gland to mark out its territory. This is one way the dominant buck can inform others of his presence.

the male.

Before the final approach and mating the male squirrel performs an elaborate tail display. He stops a short distance from the female, turns broadside on to her and waves his tail horizontally a few times; then he moves round in a wide circle. Finally, with the hairs erected as fully as possible, he brings his tail down over his back in a slow, deliberate movement, remaining like this for up to a minute. Such elaborate visual displays have only evolved in diurnal species where vision is important.

In nocturnal species, such as most carnivores, courtship is less elaborate and the senses of smell and hearing appear more important than sight. Mustelids, such as the pine marten and otter, frequently scent-mark and urinate as part of the pre-mating procedure; and it is probable that hormones released by the female as she comes into heat result in the formation of particular smells which signal her sexual condition to potential mates. Small rodents may also use scent in this fashion: experiments with captive bank voles have shown that unmated females in the presence of males (but not in actual mating contact) will be induced into breeding condition, but in the absence of males this will not happen. Similar effects have been found in other rodents, such as the house mouse.

Assessing the prospect Judging the capability of a male to be a good mate and parent is obviously important for a female if she is to improve her own reproductive potential without prejudicing her chances of survival. This means she must compare potential mates before allowing one to be successful. At the same time, of course, the male may be doing the same thing and moving around many females. However, he may be less choosy than she is.

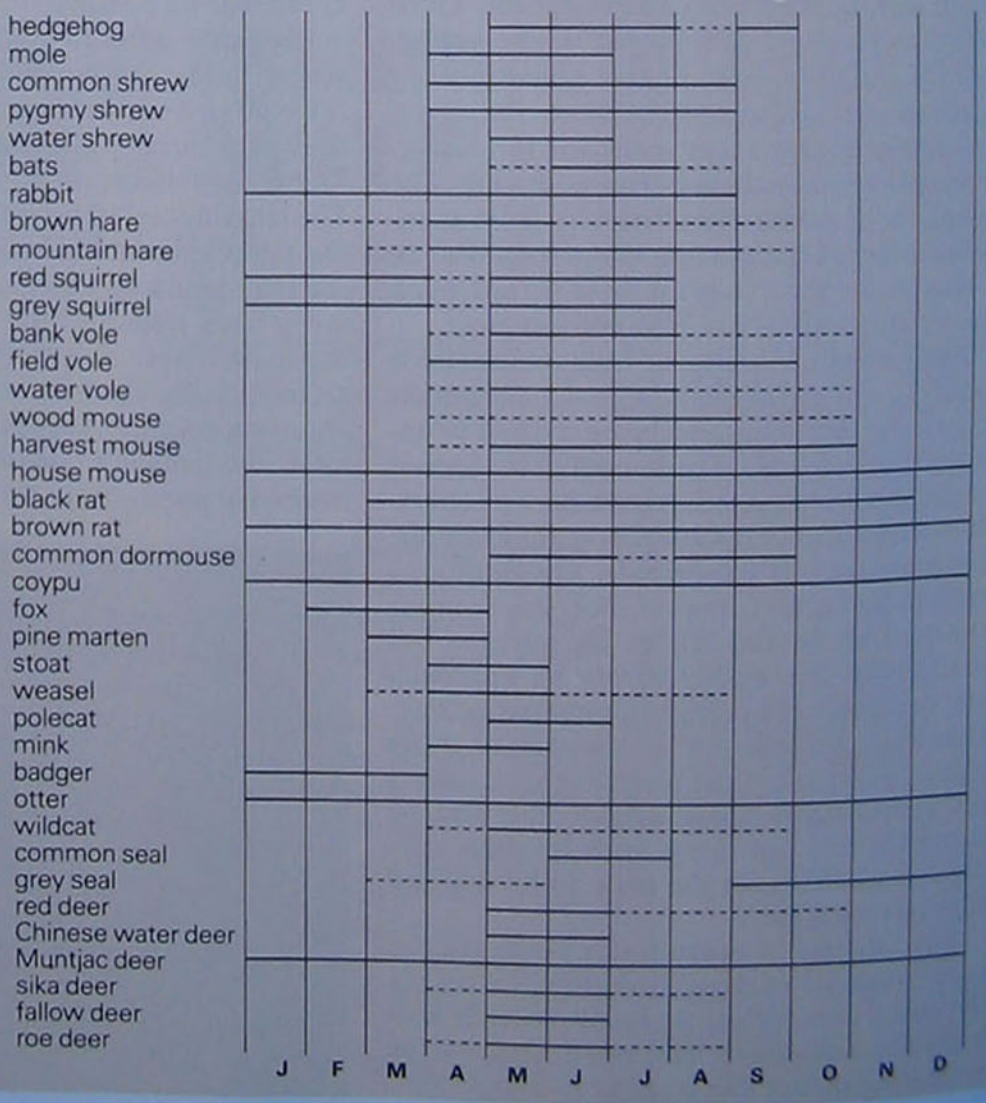
Above: A dog fox courting a vixen. Her courting calls are heard in winter.

Right: Hedgehogs mate after a lengthy courtship ritual in which the female bites and butts the male while he snorts and hisses.

With solitary mammals there may not be much opportunity for comparing potential mates, but with social species this is clearly an easier task, and many species have a period of conspicuous inter-male competition. The 'boxing' of male hares in spring is an obvious example. Another is the male red deer, which is a polygynous animal (having more than one female partner); the male red deer has a distinct rutting season when a number of males compete for a harem of females, males moving to areas favoured by hinds and rounding up as many as they can hold, to defend against challenging males.

Each autumn the Scottish Highlands resound to the barks of rutting red deer. In-

Main mammal breeding seasons (excluding whales)



dividuals assess each other's fighting potential through roaring. The original harem holder roars at the challenger, slowly at first but then at an increasing rate. If the defender can roar at a faster rate, then the intruder usually retreats. The stags which roar well are those in good physical condition, so this is a good indication of fighting ability. At the peak of the rut harem holders may roar at intruders throughout the day and night, and since they do not feed much during this time, they show a steady decline in body weight. Weaker individuals may lose the ability to roar loudly and they are more vulnerable to losing their females to another, stronger male.

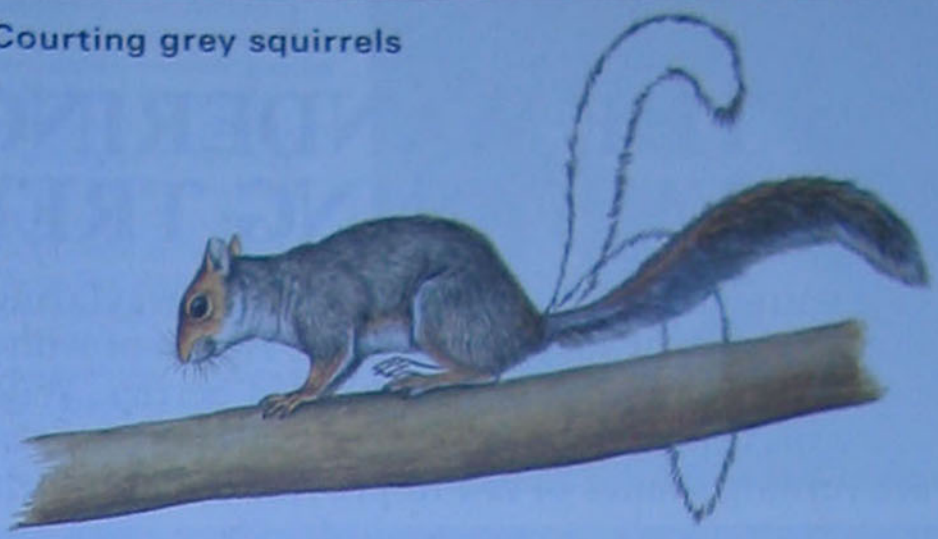
If a challenger matches or outroars the defender of a harem, he approaches and both stags engage in a parallel walk. This probably enables them to assess each other more closely, and if one is clearly stronger than the other the contest may end here. However, if the match is still relatively equal, a serious fight ensues, in which stags interlock antlers and push against each other. The contest is ultimately decided on strength–often related to body weight–and skilful footwork. These elaborate assessments of ability help to reduce the number of escalated fights, and so minimise the harm which can be caused to the combatants.

Scientists think that the 'porpoising' behaviour of common seals in late summer and autumn is a sexual display prior to mating which may involve assessment of potential mates as with the red deer, except that simple monogamous (having only one mate) pairing of an individual male and female occurs here. They bob up and down in the water, often leaping right out as they travel along the surface at speed. They may also circle around, sometimes on their backs, and even turn somersaults in the water. This display is found in a number of seal species, particularly the harp seal of North America and Greenland, but variations of this behaviour may also be seen in the common harbour seal.

Although it has not been tested, we may speculate that the ability to porpoise and chase around in the water may reflect the ability of that animal to be a good mate and parent. Such species as the common and grey seal, which spend much of their time in the open sea, often dispersed widely as they forage for food, need the opportunity to locate potential mates. To achieve this, both species come to land for pre-breeding assemblies.

Behaviour on land differs a little between monogamous species such as the common seal, and polygynous species, such as the grey seal. Bull grey seals acquire a territory either on land or in the sea adjoining a breeding beach. Cows enter this territory but are not actively gathered by the bull in the way that red deer hinds are gathered by the stags; once within the territory, however, the bull will expend much energy defending his potential mates from intruders.

Courting grey squirrels



The male grey squirrel approaches the female, flicking his tail back and forth and stamping his feet as he follows her along the branch. The female moves off, but the male immediately goes after her.

The female finally turns to face the male and growls at him. He displays for a moment, calling and waving his tail in a circle, before he makes his final approach to mate with her.

Left: A boar badger setting his scent or 'musking' the sow. Courtship and mating can occur at any time between February and May, but the fertilised eggs do not implant into the wall of the female badger's uterus until about mid-December.

Below: Grey seals mating on North Rona in autumn. Male grey seals are polygynous and acquire territory on the beach or in shallow water. They defend their potential mates from intruders.

THE WANDERING WAYFARING TREE

From spring through to late autumn the wayfaring tree adorns the roadsides of southern Britain. Heads of white flowers in May are soon followed by bright red berries. With the arrival of autumn the berries have turned a glossy black and the leaves are turning shades of red to provide a final touch of colour.

Below: A wayfaring tree (*Viburnum lantana*) in flower. Its requirement for a dry, well-drained and preferably alkaline soil limits its distribution in the British Isles: it is common only in southern England (except the West Country) and the south Midlands. On the Continent, however, it is a common shrub throughout central and southern Europe, and extends into north Africa and western Asia.

The name 'wayfaring' tree seems an appropriate choice for this roadside plant, yet it arose through a misunderstanding. The Latin name, 'viburnum', gave rise to the French word for the wayfaring tree, 'viorne'. This was mistakenly thought by the 16th century herbalist, Gerard, to derive from the Latin word 'via', meaning a road. So he named it the wayfarer's tree – it seemed to him a suitable name because he encountered it frequently on his journeys between London and Canterbury. The name 'wayfaring' tree has stuck ever since.

The wayfaring tree grows best on chalk or limestone soils, such as those found between London and Canterbury, but it is occasionally seen growing elsewhere provided the soil is dry and well drained. It is most common in the southern counties of England and the south Midlands, although it is absent from the West Country and parts of East Anglia. In Wales it is native to a narrow strip along the south coast. It is not thought to be native to areas north of Yorkshire, although it has been introduced to Scotland, particularly in the lowlands. It is, however, entirely absent from the Scottish islands and the Isle of Man. In Ireland the wayfaring tree is not native but it has been introduced to a few places.

Woods and hedgerows are the most likely habitats in which to find a wayfaring tree. It sometimes forms small, rather open thickets and can produce suckers which, given the chance, rapidly invade grassland and other open habitats close by.

Sizeable shrub Despite its common name the wayfaring tree rarely grows into a tree. It almost always remains a shrub, though sometimes a substantial one reaching a height of 6m (20ft). It has a regular branching pattern and its buds are borne naked on the shoots – that is, the buds have no protective scales to cover the undeveloped leaves. Instead they are insulated from the frost and cold weather of winter by a coating of hairs, giving the buds a greyish, felted look. The presence of naked buds on the shoot distinguishes the wayfaring tree from the other members of its genus, *Viburnum*.

The leaves are borne in opposite pairs on the shoots. They have a rather wrinkled appearance and are oval or slightly heart-shaped with finely toothed margins. They may reach a length of 10cm (4in). The upper surfaces of the leaves, and the young twigs, are covered with the same greyish hairs found on the buds. The lower surfaces of the leaves are also covered with hairs, but here they are much thicker and woollier in appearance. While the hairs on the buds are there to provide protection against the winter, the hairs on the leaves clearly perform a quite different function because the leaves are shed in the autumn. The purpose of these is to prevent the leaves from losing too much moisture in the dry habitats that the wayfaring tree often prefers.

Stems for withies The distinctive white

Right: A flowering head of a wayfaring tree. All the flowers are similar to each other – unlike another species of *Viburnum*, the guelder rose, in which the flowers on the outside of the head are much larger than those on the inside. Each flower is about 5mm across and contains five white petals fused together. Inside this tube are five conspicuous yellow stamens. The flowers of the closely related elder have the same structure.

Above: Young berries of a wayfaring tree. The berries start off green but soon turn a bright red (right) before becoming a shiny black in early autumn. Each berry is about 8mm long and oval with a fleshy interior, inside which are embedded several seeds. The berries have too sharp a taste for humans but they are a popular source of food for birds, which devour them eagerly and so disperse the seeds. The juice from the berries was once used to make black ink.

Below: The evergreen laurustinus flowering in February. Unlike the wayfaring tree, which flowers in early summer, the laurustinus flowers from November onwards, sometimes through to April during a mild winter. Typically for a broad-leaved evergreen, the leaves are thick and glossy. Unlike the wayfaring tree the upper leaf surfaces lack hairs and the undersides have tufts of hairs in the angles between the veins.

woolly undersides of the wayfaring tree's leaves have given rise to many alternative names for this tree, such as mealytree, cotton-tree, whitewood and hoarwithy. The last of these colloquial names also refers to the use of the supple young stems for binding and tying things together, a withy being any stem or twig flexible enough to be used for these purposes. Withies from the wayfaring tree were used to tie up bundles of faggots and as hoops for fastening gates. They also provided switches (small tapered rods) for driving cattle, and handles for whips, from which come two other colloquial names for the wayfaring tree – twistwood and whipcrop.

Elder-like flowers The wayfaring tree flowers in May and June, each shrub producing numerous tiny white-petalled flowers borne in large umbel-like clusters up to 10cm (4in) across. Superficially the flower heads resemble those of an elder bush – the two species belong to the same family, the honeysuckle family – but the elder flowers slightly later in the year, usually in June and July.

In July the flowers are followed by fleshy oval berries, again resembling those of elder. The berries of a wayfaring tree are green when young but soon become bright red and eventually turn black and shiny when fully ripe in about September. The berries are not poisonous but they have an extremely tart taste and are not recommended for eating.

As the year advances the wayfaring tree becomes even more colourful and the leaves take on their autumn hues of red, providing a striking contrast to the clusters of shiny black berries.

Close relative Another member of the same genus – *Viburnum* – is sometimes found growing in the wild. This is the laurustinus, a species that, though not native to the British Isles, has become naturalised here in some areas.

The laurustinus is native to the Mediterranean region, particularly southern Italy and north Africa. It was first introduced to Britain during the 16th century and has been cultivated in gardens ever since, sometimes escaping to the wild.

Like the wayfaring tree, the laurustinus is a shrub, though smaller – usually between 2m (6ft) and 4m (13ft) high – and with a domed crown. It differs from the wayfaring tree in being evergreen, as its thick, leathery, dark green leaves suggest. It bears a great many branches from ground level upwards.

The flowers of the two species are similar, except that the outsides of the laurustinus petals may be tinged pink. Also, the flower heads are often smaller on laurustinus, usually 5-10cm (2-4in) across, and they appear at a quite different time of the year, opening in November and often continuing to flower through the winter until April, depending on the severity of the weather.

Although laurustinus flowers prolifically in Britain, it rarely produces fruits here. When they do appear, however, they are smaller than the fruits of the wayfaring tree, and a striking metallic blue in colour. Nevertheless, the fact that laurustinus occasionally sets fruit in Britain has allowed it to escape from gardens and establish itself in the wild.

Different specimens of laurustinus can be very variable in such features as leaf shape, size of flower head and so forth. This suggests that there are a number of different races in this species that have become adapted to different climates. Some, for example, are adapted to the warmth of the Mediterranean while others – presumably those that set fruit here – are adapted to the cooler, moister climate of Britain.

NIGHTINGALES: SUMMER NIGHT SINGERS

The nightingale is justly praised for its tuneful singing, but it cannot excel in all things: despite its wonderfully varied musical performance, it is an unobtrusive, dull brown bird, here for a short breeding season spent hiding in the thickets.

The nightingale combines the extremes of delightfully melodious singing and a generally uniform, unremarkable plumage. It is about half way in size between the robin and the song thrush, two fellow members of the thrush family. In its general posture the nightingale is comparable to these two birds. Its plumage, however, is considerably less colourful than that of other members of the thrush family, being chestnut-brown all over the upperparts and paling to a rufous fawn beneath. The most interesting feature is the tail, which is frequently flicked while the bird is perching, sometimes catching the light and revealing a rich rufous quality.

Like the robin's, the nightingale's eye is large and dark; but the legs are stouter than those of the robin. Young birds, before the autumn moult of their first year, have scaly, pale fawn fringes to many of their feathers, and unless you catch a glimpse of the tail you might easily mistake them for young robins.

Thicket dweller According to one country saying, the distribution of the nightingale, the cowslip and the hop have much in common in England; and this is indeed broadly true. Most nightingales breed to the south of a line between the Severn and the Humber, preferring habitats with a well-developed and dense undergrowth. Thus most are found in woodland areas, usually of deciduous trees and very often of oak, with the mature trees widely spaced. Towards the north-western fringe of this breeding range, the wooded slopes of river valleys are particularly favoured.

Over the last few centuries, the distribution of the nightingale right across Europe has contracted considerably. Possibly this is partly due to wholesale trapping (particularly on the Continent) of nightingales for caging as song birds or, even more unpleasantly, for sale in delicatessens. Though this does still occur, it seems more likely that the major factor in the decline is the loss of the appropriate type of deciduous woodland. This is due both to modern farming, with its demands for full land usage and increased field sizes, and to modern forestry practice, in which broad-leaved woodland is replaced by dense plantations of conifers.

Above: The nightingale has three main adaptations to its life in the thickets. The beak is suited for taking large and small invertebrates as well as berries. The legs are strong enough for ground foraging, and the large eye enables it to see well in the dense undergrowth.

Previous page: The rich tone of the plumage is seen on the rump and tail.

Below: The nightingale is restricted to the south and south-east of England.

Watching for nightingales Generally, nightingales are shy, rarely venturing into the open, so for many of us this is a bird far more often heard than seen. Considerable patience, and quiet watching from semi-concealment in an area with several nightingale pairs – and preferably with some paths to provide open ground – is required to obtain even fleeting glimpses. If you are lucky, a male nightingale may choose to sing from a perch in your line of sight, head thrown slightly back, throat bulging, giving you a chance to see the performance as well as hear it.

More often, apart from the song, much of what you hear in the undergrowth is the surprisingly varied repertoire of 'chack' and 'churr' noises with which the nightingale deters intruders from approaching its place of concealment. You may also hear the soft 'weet' call that the pair use to keep in contact.

Our best night singer The voice of the nightingale, heard solo at dead of night, comes through the clear, warm early summer air as one of the most delightful bird songs in the world. The song period is, however, short, generally spanning the second half of May and the month of June, but rarely continuing as late as July.

For quality, range and versatility the nightingale's voice cannot be matched, even among British birds with their exceptionally rich songs. Part of the enjoyment stems from

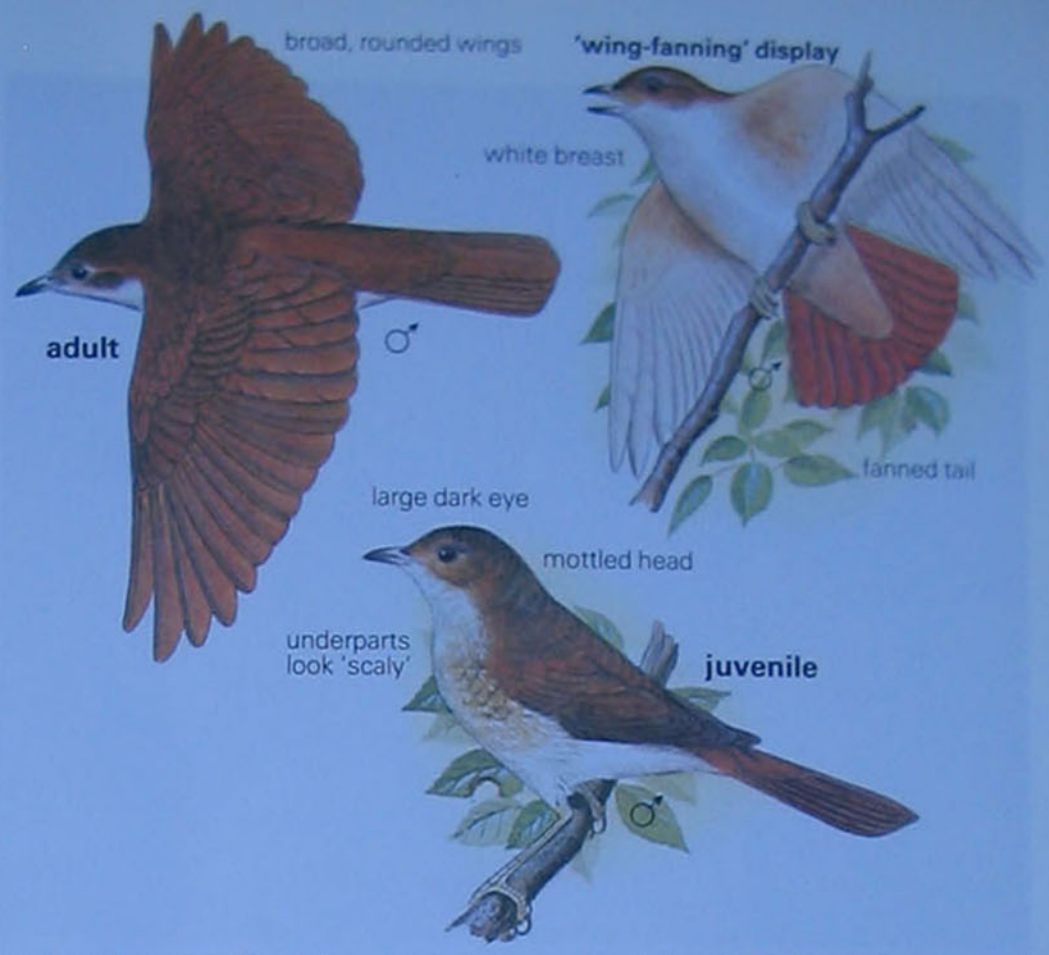
Right: The nest is either low down in the vegetation – frequently bramble or nettles – or actually on the ground. It is always in an overgrown and inaccessible spot. In many cases nightingale pairs return to exactly the same spot each year.

the sheer variety–from throaty chuckles to far-carrying whistles–and part from the quality of the tonal range, from rich, deep phrases to the purest of treble-like trills and flourishes.

Special adaptations In the shelter of its habitat of thick undergrowth, the nightingale spends much of its time concealed from view. It is one of the more terrestrial birds in the thrush family. Strong legs and large eyes are adaptations to this mode of life, as also is the beak. Though not so stout as the conical beaks of the finches, nor so fine as that of insect-eaters such as the pied wagtail, the well pointed but strong beak of the nightingale allows it to tackle most soil and litter-dwelling invertebrates. These range from tiny insects and spiders to caterpillars and worms. The beak is also suited to feeding on berries as they become available later in the month. At this time they are invaluable as a sugar-rich resource to help the nightingale put on fat as a fuel reserve for the long migration south.

The breeding season Nightingales perform a pairing display which is rarely seen because of the dense cover in which it takes place. It involves much ritualised posturing, with wings drooping and fluttering, and with tail fanned. After the display, the nest is built low in the vegetation or, quite commonly, on the ground. It is always well concealed from disturbance by humans and large predatory mammals or birds, although it is not safe from such predators as weasels or mice. The nest is basically constructed of dead leaves, usually those found lying nearby. Those found in England are most often held together by fine twigs or stout grasses. The lining of the cup is of fine grasses and hair, and the normal clutch is four or five (occasionally six). The eggs are brown, so densely speckled as to appear almost uniformly coloured. Because of their early departure on migration, there is normally time for just a single brood each season.

Long-distance migrants Nightingales desert their breeding woods from late July onwards. Ringing results indicate that most nightingales cross the Mediterranean in autumn and fly over the western margins of the Sahara Desert. Their wintering areas are in tropical West Africa. As with many other migrants, individual breeding birds often return to precisely the same patch of dense cover in successive years, for unless the site has been cleared by man, nightingales keep to their traditional nesting grounds.



Nightingale (*Luscinia megarhynchos*). Summer visitor breeding in thickets. Splendid song audible at night. 16.5cm (6½in).

Below: After an incubation period of about a fortnight, the brood hatches. In their earliest days, nightingale chicks have the same speckled appearance as young robins–a resemblance which continues into the juvenile stage. The season is too short for more than one brood.

Night singing birds

It is interesting to note that nightingales sing a great deal during the day as well as the night, but in the daytime their song tends to be drowned by the richness of other birdsong heard at this time. However, *why* they sing so much at night is intriguing, and by no means well understood. Few other songbirds sing at night, but two that do, the grasshopper and the reed warblers, are both birds of dense cover, like the nightingale. Also like the nightingale, they are summer visitors to this country, migrating by night to and from wintering areas in Africa.

One theory is based on the observation that males usually migrate some days in advance of the females. On arrival, they set up territories and defend them by song, and then it is thought that they sing to the night skies to attract the females as they pass over. Although plausible in this context, the theory leaves unexplained the fact that all these species continue their nocturnal singing until well into the breeding season.

SOIL-DWELLING DIGGER WASPS

Entomologists have long been fascinated by digger wasps–a group of soil-dwelling solitary wasps which excavate many-celled burrows and then stock them with paralysed flies and other invertebrate prey for their larvae to feed on.

When wasps are mentioned, most people are sure to think of one of our seven species of social wasps, that is those living in large communal nests headed by a single fertilised female (the queen). However, there are in addition to these social wasps, a further 130 or so British species–the solitary wasps. These do not live in large colonies, but construct their own individual burrows. In suitable nesting areas several females may be found excavating burrows near one another, but each one is quite distinct and there is no communal activity.

In each burrow the female makes a series of cells, perhaps as many as 25 in one season, which she stocks with appropriate prey for her offspring. She uses a variety of habitats for the burrow, but usually digs in rotten wood or soil. The soil-dwelling species are usually called digger wasps. Most of them are extremely wasp-like in appearance with their black and yellow liveries, but are rarely noticed as they do not enter houses or attack fruit. They have no workers so the species consists simply of males and fully fertile females.

Above: A field digger wasp (*Mellinus arvensis*) dragging a paralysed fly to its nest burrow (below). This may be 11-14cm (4½-5½in) deep and comprise up to ten cells, each stocked with several immobilised flies.

Field digger wasp One of the commonest species is the field digger wasp, found from July to September. It is fairly large, reaching a length of 11-14mm (⅜in), and has black and yellow colouring that is not unlike that of some social wasps.

The female excavates a sloping burrow 30-50cm (12-20in) deep in bare sandy soil, with the entrance often hidden by a leaf or stone. She removes the soil with her jaws and front legs, gathering it into lumps held between her head and forelegs, and then backs out of the burrow to deposit the soil a few centimetres from the entrance. She excavates up to ten cells leading off from the burrow, making them one after another as each is stored with paralysed flies.

Catching the prey The field digger wasp's prey consists of the most plentiful medium-sized fly species in the area. The female hunts for flies, mainly near dung, although she also searches on the leaves of trees. Her method of attack is to alight a short distance from the heap of dung, and then to crawl towards it and stalk a settled fly.

When she arrives within an inch of the victim, she leaps on to its back, holding it with her legs and grasping a wing with her mandibles. She then bends her abdomen round and stings the fly from below. When the fly ceases to struggle, she turns it over, grasps it with her jaws, and withdraws her sting. The female wasp flies back to her nest with the prey and drags it into her burrow backwards.

Each cell is stocked with as many as ten flies, generally placed with their heads pointing inwards and occupying about two thirds of the space. An egg is placed on the last fly in the cell before the passage to the main tunnel is filled with soil obtained from the next cell.

When the egg hatches, the purple coloured larva consumes the paralysed flies over a period of a few days and then spins a soft, yellowish, parchment-like cocoon. It rests in this cocoon in a dormant state until the following spring when it pupates, before emerging as an adult.

Frog-hopper prey The two-girdled digger

Identifying digger wasps

Above: Two-girdled digger wasp (*Argogorytes mystaceus*).

Above: Large spurred digger wasp (*Nysson spinosus*).

Above: Common spiny digger wasp (*Oxybelus uniglumis*).

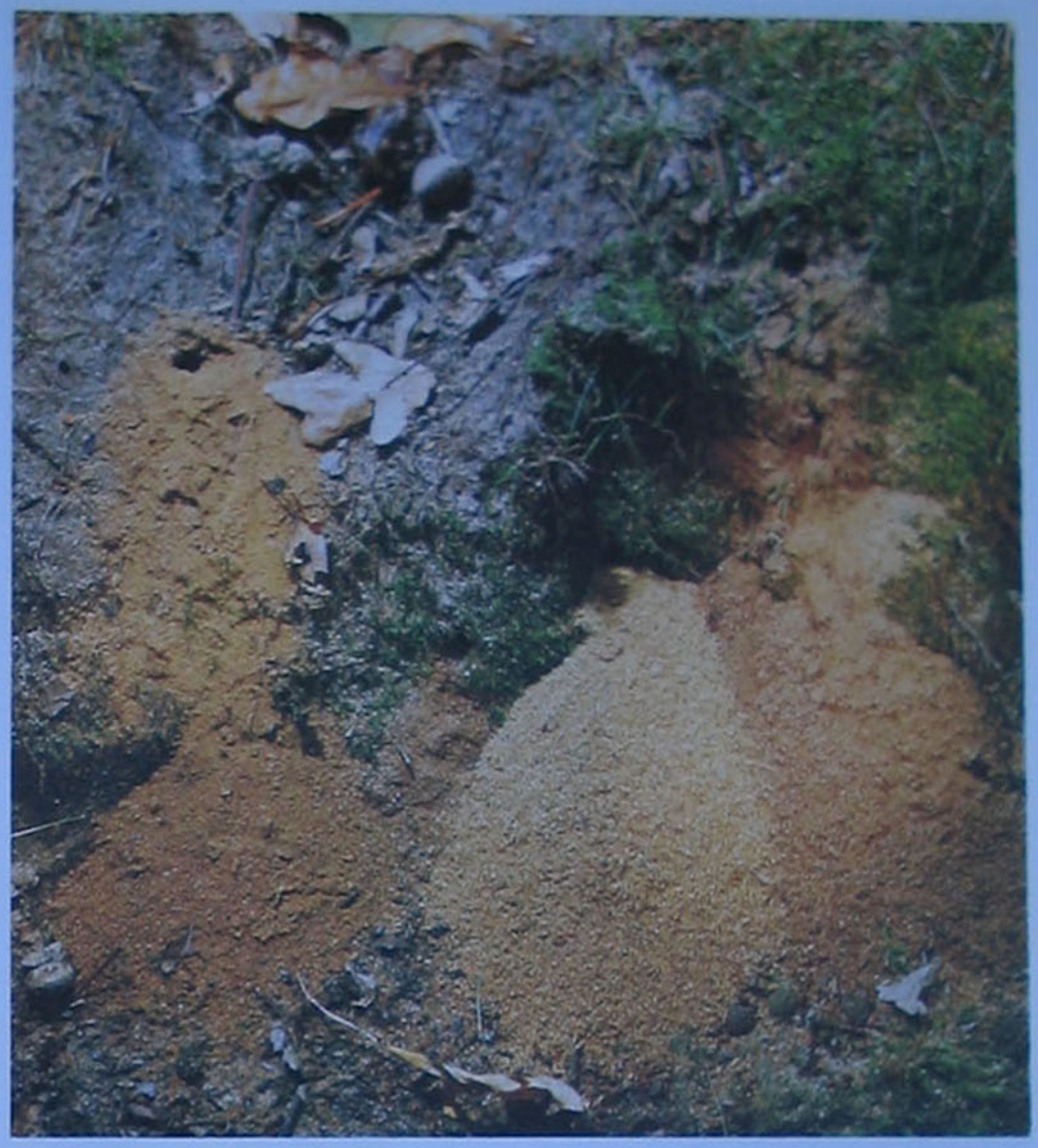
Above: The female slender-bodied digger wasp (*Crabro cribrarius*) is 10-15mm ($\frac{1}{2}$-$\frac{3}{4}$in) long and is found in June and July, resting near plants or flying at speed.

wasp is a darker insect with the yellow markings on its abdomen reduced to two complete but narrow bands and two short bars. Like the field digger wasp, the female digs a nest in sandy soil, excavating vertically for about 10cm (4in), and then horizontally. Six to nine cells are dug.

This species preys on the nymphs of frog-hoppers, which the female extracts from their frothy cuckoo spit shelters. She carries the captured nymphs back to the nest one at a time, holding them beneath her body with her middle legs. She swiftly enters the nest, head first, shifting the grip on her prey to her hind-legs. Each cell is stored with 20 or more nymphs, and then an egg is laid and the cell is closed.

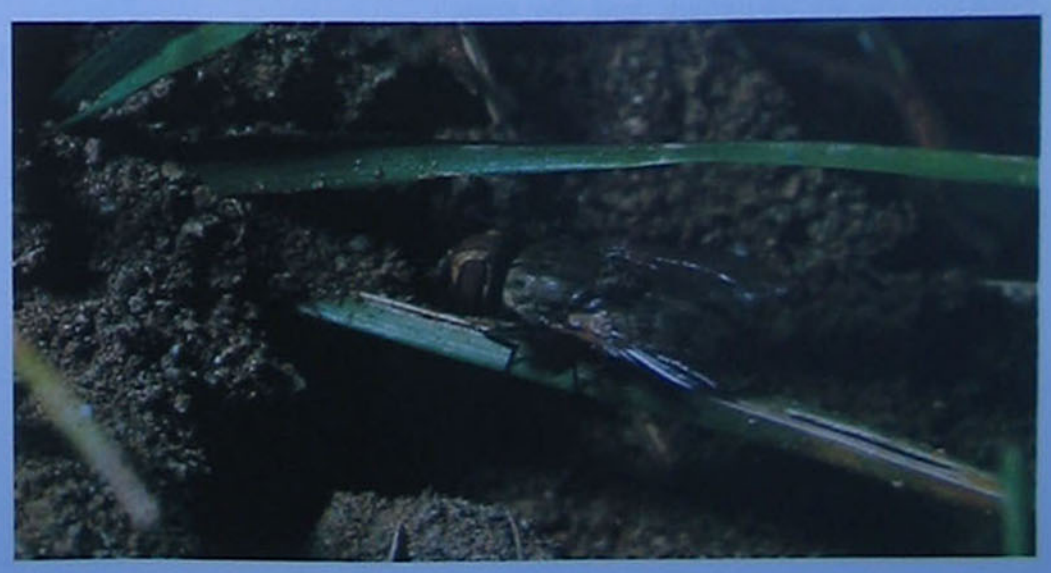
Another species, the large spurred digger wasp, acts as a nest parasite of the two-girdled digger wasp. It waits patiently by the nest until the owner flies away for more prey, and then enters it and lays its own egg secretly–perhaps under the wing-pad of one of the stored nymphs. The parasitic large spurred digger wasp has also been observed opening up closed burrows to gain access to the cells, but carefully closing the burrow afterwards. When the egg hatches into a parasitic larva, it first eats the wasp's egg and then consumes the frog-hopper nymphs.

Weevil catcher Digger wasps of the genus *Cerceris* are called tailed-diggers, as they have



Above: The spoil-heaps on this bank give away the locations of these slender-bodied digger wasps' nest burrows. These are usually excavated in sandy ground.

Below: Parasitic flies often plague digger wasps, shadowing them, and then entering their nests when the rightful owner is away. The flies lay their own eggs in the wasp cells that are still open, and then when the fly larvae hatch, they feed on both the prey and the wasp larvae.



particularly strong plates at the ends of their abdomens which are used for pushing soil out of the burrow. They dig more or less vertical shafts in fairly hard ground with their legs, and then use the end of their abdomens as pistons to push the soil out so that it stays as a heap on the surface. The entrance is in the centre of the mound, which appears to be an important marker, helping the wasp to find its nest again.

The sand-tailed-digger wasp is common on sandy heaths in southern England. Like others of the same genus, the abdominal segments of this species are wider in the middle than at the ends where they adjoin. The abdomen has alternate bands of yellow and black.

This species specialises in catching weevils as prey, often selecting just one species in a particular area. Although the weevil prey are stung between the thorax and the abdomen where the main nerve centres lie, they may stay alive and fresh for as long as a month.

The nest burrow goes down vertically for about 6cm (2in) and then becomes gradually horizontal, ending in an oval cell. The longer the nest is used, the more cells are added at the sides – sometimes as many as six.

Other species Another similar species, the ornate tailed-digger wasp, uses solitary bees for prey, particularly those of the genera *Andrena* and *Halictus*. It catches these bees on the wing, preferring those which are heavily laden with pollen. The wasp knocks the bee down near its colony and, holding it by the neck, stings it under the thorax. The wasp then grips the bee's antennae with its jaws and flies off to its own burrow, carrying the bee beneath its body. Occasionally it kneads the victim with its jaws and feeds on the body fluids. If the prey is especially heavy, the wasp may transport it in stages. As many as eight bees are packed into each cell.

A common species found in June and July is the slender-bodied digger wasp. Measuring 10-15mm ($\frac{1}{2}$-$\frac{3}{4}$in) long, it is frequently seen flying quickly or sitting near plants where medium-sized flies can be found. It swoops on these flies, often appearing to miss, and then stores them in the cells. The extensive yellow markings on its abdomen, and the male's expanded front tibiae (which are yellow with black markings) are the key to identifying this species.

Dog-like digger The common spiny digger wasp is only 5-8mm ($\frac{1}{4}$in) long, and digs short burrows in sandy soil, raking out the soil with her legs rather like a dog. The burrow comprises a single cell at the end of the shaft, but no side cells. When the female has finished the burrow, she closes the entrance and flies around it, memorising the location.

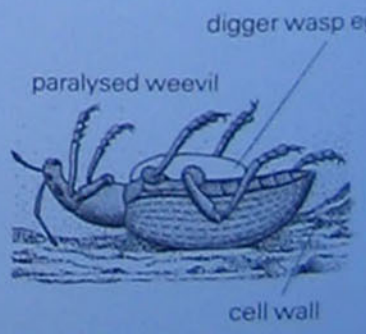
Her prey is, again, small flies, but she differs from other digger wasps in her method of carrying the victim – it is borne upside down, still impaled on her sting, so that it trails behind, supported by her hind legs.

Above: A sand-tailed-digger wasp (*Cerceris arenaria*), laden with prey, alights outside its nest burrow. This wasp which specialises in catching weevils, selects the same species in any given locality, often trapping large numbers of a species which is unfortunately quite rare. Although the weevil is stung by the wasp when caught, it may stay alive, sometimes for as long as a month. The digger wasp carries the prey beneath its body (as shown here) and flies straight into its nest.

Left: The quantity of sand outside this burrow gives some idea of its depth. Notice the discarded flies on the spoil-heap – they were probably too large.

Inside the wasp cell

The sand tailed-digger wasp, like all other digger wasps, stocks the cells in its nest burrow with its own species of prey – in this case weevils – which have been paralysed. The digger wasp places the victims neatly on their backs, and then lays an egg in each cell, before closing it up. The hatching larvae thus have a ready-made food supply.



ROSETTE PLANTS: A LOW PROFILE

Outside the flowering season many of our most familiar plants consist of no more than a cluster of leaves hugging the ground in an arrangement called a rosette. This helps the plant to survive the attentions of grazing animals and allows it to thrive in a range of inhospitable habitats.

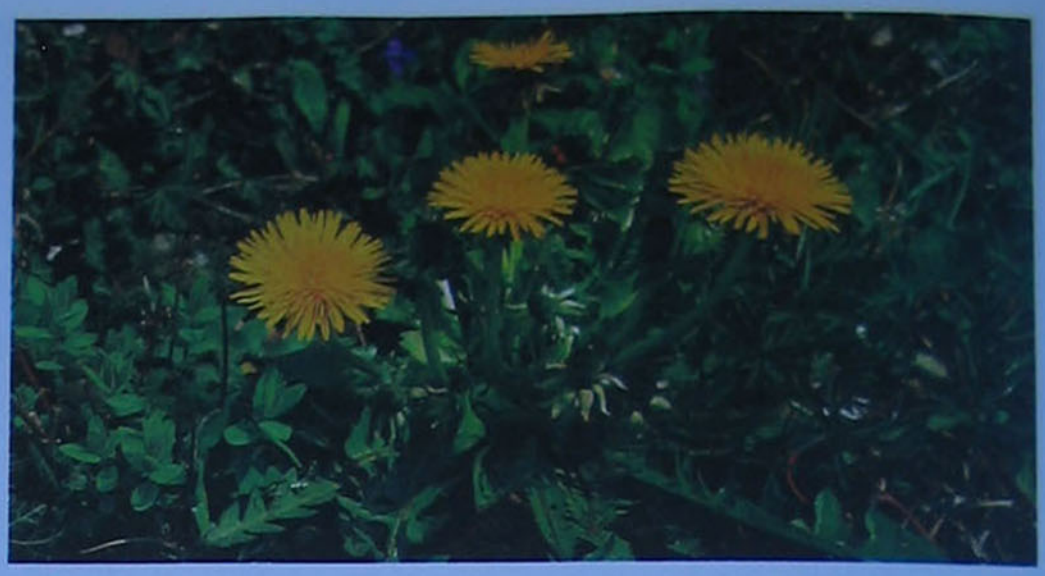
Above: Some rosette plants occur as isolated species in a family whose other members have different leaf arrangements. Others belong to families in which the rosette habit is ubiquitous. An example of the latter is thrift, which belongs to the sea-lavender family, the Plumbaginaceae. All British members of this family have a low-lying rosette habit to help them survive the sometimes fierce salt-laden winds of the coastal habitat. In the case of thrift, only during its flowering period does it reach a height of more than a few inches. Thrift also has extremely narrow leaves to help reduce water loss through increased transpiration—always a danger with plants growing in exposed coastal sites.

One of the principal ways by which we recognise flowering plants when they are not in bloom is by the arrangement of their leaves. This arrangement varies greatly from one kind of plant to another but is usually characteristic for a particular species.

The most common arrangements are for the leaves to be borne along the stems in pairs, one on each side of the stem, or for the leaves to be staggered along the stem so that those on one side lie midway between those on the other side. The first arrangement is called opposite and the second alternate. In both, the leaves are borne along the stem, but in one much less common arrangement, called a rosette, the leaves radiate from the base of the stem in a star-shaped pattern. Strictly, the rosette is distinguished from other leaf arrangements by the absence of a stem between the leaves rather than any special arrangement of the leaves themselves.

Each of these different leaf arrangements is suited to a particular manner of growth and way of life. Leaves spaced at intervals along a stem are characteristic of plants with spreading branches, such as trees, shrubs and large herbaceous plants. On the other hand, the rosette habit of growth is, by its very nature, found only on smaller, single-stemmed plants.

Disadvantages Rosette plants are found in a great many different plant families and in-



Above: One of our most familiar rosette plants is the dandelion.

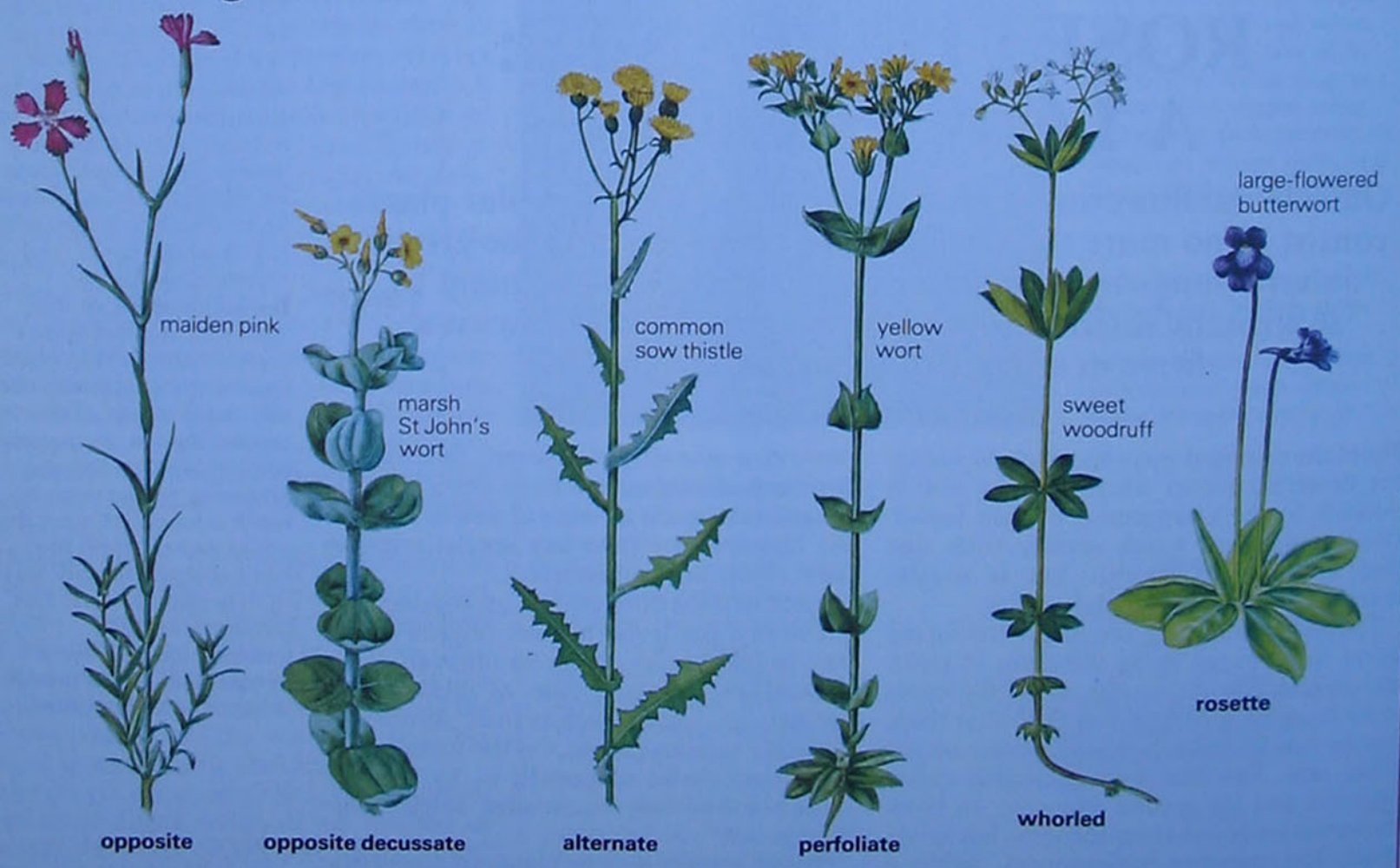
Left: The stemless thistle is an example of a rosette plant whose close relatives all have normally developed stems. In flower, this species grows to a height of only 3-5cm (1-2in).

Below: The rosette arrangement of leaves is only one among several possibilities. Some of the most common ones are shown below.

clude some of our most common species, such as daisies, dandelions, plantains and bluebells. This growth habit, therefore, clearly gives the plant a certain competitive edge over those with other leaf arrangements. Yet it also has its drawbacks, which are more immediately apparent than its advantages.

In most plants the leaves are arranged so that they overlap as little as possible. This maximises the surface area of the leaves receiving sunlight and so increases the rate of photosynthesis. In rosette plants, the leaves necessarily overlap and shade parts of each other from the sun. This is, therefore, a far less efficient system than others for absorbing sunlight.

Leaf arrangements



With this limitation it is not surprising to find most rosette plants growing in the full sunlight of open habitats rather than in the shade of woods. To help reduce the effects of the rosette habit the leaves of such plants are arranged radially around a central axis to keep the amount of overlapping to a minimum – virtually no stemless plants have leaves arranged in ranks because the leaves would overlap one another so much. Furthermore, the young leaves arising at the centre of the rosette are often more or less erect, becoming close to the ground only after the older leaves begin to die.

Advantages Although the rosette habit has inherent disadvantages, it also has redeeming features – as indeed it must, otherwise natural selection would scarcely have favoured the evolution of this growth form in so many different plant families.

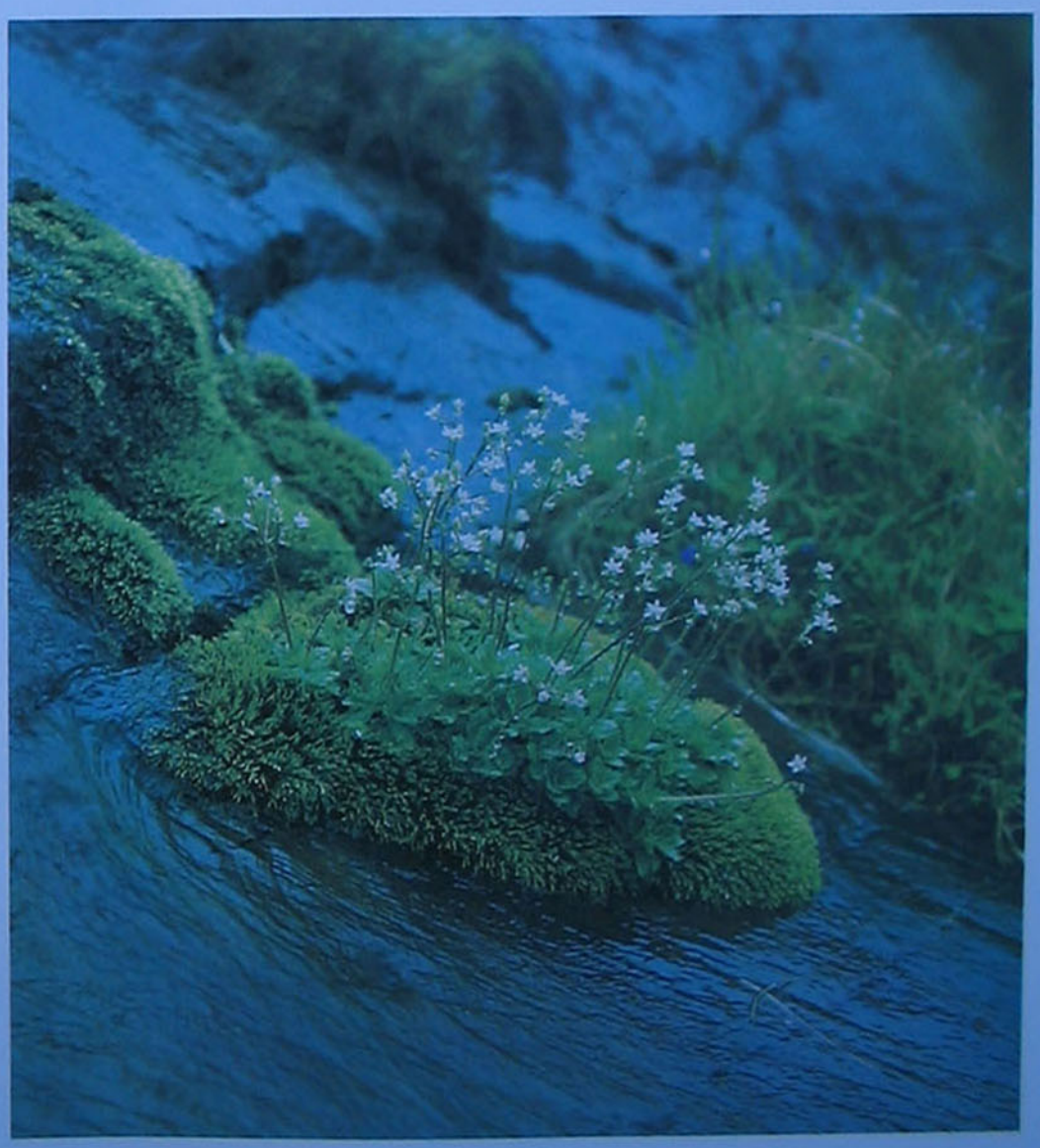
Probably the greatest advantage of the rosette habit is the protection it offers the plant against grazing animals. The leaves and young flower buds are so close to the ground that animals find it very difficult to eat them. It is noticeable that even plants which mature to an erect habit of growth have the rosette habit when young to provide some protection until they become established. Similarly, biennials and perennials that die back to their underground parts over winter produce rosette leaves when they resume growing in spring. Other plants, such as lemon balm, reduce their aerial parts to a rosette as a means of surviving severe winter weather. This reduces damage that would occur to taller, more exposed stems and leaves.

Rosette plants are also much more resistant to damage by trampling; more erect species may not recover if their upright stems are snapped or trodden down. Just how effectively the rosette arrangement enables plants to survive being trampled can be seen by looking at a well-used footpath on gravel or soil. On the path itself there is likely to be only rosette plants such as plantains, daisies and dandelions, but at the sides of the path, where there is little trampling, you will find more erect plants.

Surviving the weather Another advantage of the rosette form is that its very compactness makes a plant less vulnerable to harsh climatic conditions, so enabling it to thrive in a variety of seemingly inhospitable habitats. For example, the continuous winds of an exposed coastline cause plants to lose water rapidly by speeding up transpiration from their leaves. The rosette habit minimises this effect because it exposes much less leaf surface to the air than do other leaf arrangements. Furthermore, the stomatal pores of the leaves, through which the water transpires, are most numerous on the undersides, which in rosette plants are largely concealed by being pressed close to the ground. Thrift and two coastal plantains – the sea plantain and the buck's-horn plantain – are examples of rosette plants that grow well on windswept shores.

For the same reasons the harsh conditions of high mountains also favour rosette plants. For example, several rosetted species of saxifrage – including the starry saxifrage, the clustered alpine saxifrage and the tufted saxifrage – are plants of high mountains, their rosette form protecting them against both the wind and the cold.

Rosettes and storage organs Many rosette plants have a particular type of storage organ, either a bulb or a taproot. Underground bulbs consist of swollen leaf bases which act as storage organs allowing the plant to survive the winter. With the arrival of the spring (or earlier) the new leaves grow out through

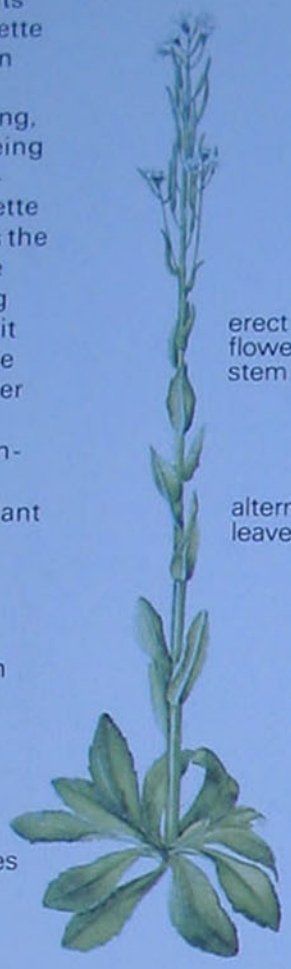


Above: The combination of a taproot and a rosette habit of growth can make a plant a formidable weed, the daisy being a notable example. Such plants used to be much scarcer before mankind began to cultivate the land.

Below: Several species of saxifrage are able to grow high up in montane areas by virtue of their rosette habit of growth. This starry saxifrage is growing above Lough Doon in Kerry, south-west Ireland.

Hairy rock-cress

Many biennial and perennial plants produce a rosette of leaves when they resume growth in spring, an example being the hairy rock-cress. The rosette habit increases the chances of the plant flowering and setting fruit before it can be eaten. Only later in the season when photosynthesis has provided the plant with enough reserves of energy does it adopt an erect habit of growth and begin to flower.



Right: Certain insectivorous plants have adapted the rosette arrangement to trap their prey. An example is the common butterwort, whose leaves have sticky upper surfaces and inrolled margins to trap any prey that touches them, including both flying insects and crawling insects. The latter can be caught only because the plant has a rosette habit with its leaves close to ground level. Once a leaf has trapped an insect, the margins roll over to enclose it and the leaf secretes enzymes to digest its prey.

Below: The rosette habit of growth is widespread in the plantain family. The buck's-horn plantain thrives in a range of habitats, from windswept shores and cliffs along the coast to more inland areas where it is to be found on open land on poor, sandy or gravelly soils.

the top of the bulb in a rosette shape. Examples of rosette plants with bulbs include most members of the lily family. Some bulb plants, such as the common twayblade, have their rosettes of leaves lying close to the ground; on other species, such as the bluebell, the rosettes are held almost erect.

Other rosette plants may have, instead of a bulb, a well-developed taproot performing the same function of allowing the plant to survive the winter. All the rosette-leaved members of the daisy family, for example, such as the daisy itself and the dandelion, have stout taproots. The advantage is that if any leaves are cut off or eaten the taproot contains enough reserves of food for new leaves to grow and replace the lost ones.

This particular combination of characteristics–a taproot and rosette leaves–is often found in the most persistent of weeds. Many such weeds can grow in the closest mown lawns, where otherwise only grasses can survive because their leaves grow from the base rather than from the tip of the plant.

Rosettes for traps The rosette habit appears in a quite different guise in our terrestrial insectivorous plants. Both sundews and butterworts trap insects with modified rosettes of leaves. On sundews the leaves have long narrow stalks and small round blades with sticky hairs; on butterworts the leaves have sticky surfaces and rolled-in margins, which combine to produce a simple yet effective trap.

'CHEESE-FRUITED' MALLOW PLANTS

Along Britain's roadsides, hedgebanks and coastline you may see a plant resembling a garden hollyhock. The plant is probably one of a dozen species of mallow, all of which have attractive flowers and fruits known as cheeses after their curious shape.

Above: All but one British species of mallow are herbaceous, the exception being the aptly named tree mallow. This plant has a shrubby, almost tree-like, form with woody stems near the base. It is native to rocky coastal areas and waste ground as far north as southern Scotland. This specimen is growing on cliffs near the Lizard in Cornwall.

The mallow family (Malvaceae) is a large and important family of plants with representatives in most parts of the world. Some of our most popular garden ornamentals, such as hollyhocks (*Althaea rosea*) and species of *Hibiscus*, belong to this family, as do a few major crops, for instance cotton, which is a species of *Gossypium*.

Twelve species of mallow grow wild in Britain; they belong to three different genera: *Malva*, *Althaea* and *Lavatera*. None of these species has any economic value, but they are all decorative plants with distinctive, showy flowers that make them easily recognisable as members of the mallow family.

Mallow characteristics All mallow flowers have five petals, coloured a shade of rosy purple, or sometimes white, with the veins picked out in a darker colour. Usually the petals are heart-shaped and narrow, and they rarely overlap one another, so the shape of each can be clearly seen in a flower. Before a flower opens out the young petals are arranged inside the flower bud in a spiral with each petal folded upon the next. When the flower fades and is ready to fall the petals reassume this pattern, though they remain less tightly folded.

In the centre of each flower is a mass of stamens, the filaments of which are fused into a tube. The base of this tube encloses the ovary; the top branches out into a number of lobes, each bearing a single anther and giving the whole tube a very distinctive 'bottle-brush' appearance.

Below each flower, at the point where it joins on to the stalk, are the green sepals forming the calyx. Below that is an extra calyx-like structure called the epicalyx. This consists of small green bract-like segments and is an important means of identifying to which of the three genera a particular mallow plant belongs. The true mallows, *Malva*, have

Above: The marsh mallow always grows near the sea, most often in saltmarshes and other brackish marshy areas, though it is also found in ditches and banks. It grows all around the coast of Britain, except for the most northerly counties of Scotland. The confectionery of the same name used to be made from mucilage extracted from the root of the marsh mallow. Today, only the very highest quality marsh mallow sweets are made in this way; most are now synthetic.

three epicalyx segments which are not joined together; mallows in the genus *Lavatera* have three segments fused into a cup; and *Althaea* species have between six and nine segments.

Cheese-shaped fruits Just as mallows can be distinguished from other plants by their flowers, so can they also be recognised by their fruits, for these are unique in the British flora. Each fruit is circular and rather flat, resembling a button. As it ripens, it divides into a number of single-seeded nutlets called mericarps. These divisions give the fruit the appearance of a cheese divided into portions. As such they form the basis for numerous country names for mallow, including lady's cheese, cheese plant, bread and cheese, and fairy cheese.

True mallows The true mallows belong to the genus *Malva*. Seven species grow in the British Isles, of which four were introduced here from the Mediterranean area or Asia and are uncommon in the wild. The three native species, however, are all frequently encountered along roadsides and in grassy areas and waste places.

The most widespread native mallow is the common mallow, a species found throughout Britain, though more common in the south than the north. This is a familiar plant to many people because its large flowers (which can be as much as 4cm/1⅝in across) produce bright displays of colour along our roadside verges and dry banks during the summer. A perennial growing to a height of 90cm (3ft), the common mallow has rounded leaves with shallow lobes and a distinctively folded or creased surface, giving them a resemblance to a fan, especially when young. The leaves contain copious amounts of a thick, gum-like sap (called mucilage) which was once used for treating bites and stings. The same thick mucilage is found inside the cheese-shaped fruits. The ripe fruits are greenish-brown and edible, the taste apparently being like that of monkey nuts, though the crisp yet slimy texture can be off-putting.

The leaves of common mallow are often spangled with small golden-brown powdery spots. These are caused by a rust fungus.

Right: Apart from being larger, the flowers of the musk mallow are similar to those of the common mallow, but the two species can easily be told apart by their leaves. Those of the common mallow are rounded with shallow lobes—the typical shape of a mallow leaf. The leaves of the musk mallow have the same shape when they occur at the base of the plant but are quite different higher up the stem, where they become finely divided into slender segments to give the whole leaf a feathery, dissected appearance.

Common mallow (*Malva sylvestris*). Perennial herb. Height to 90cm (3ft). Flowering period June-September.
Dwarf mallow (*Malva neglecta*). Annual herb. The only prostrate, non-erect mallow in Britain. Flowering period June-September.
Musk mallow (*Malva moschata*). Perennial herb. Height to 60cm (2ft). Flowering period July-August.
Marsh mallow (*Althaea officinalis*). Perennial herb. Height to 1.2m (4ft). Flowering period August-September.
Tree mallow (*Lavatera arborea*). Biennial shrub. The only non-herbaceous British mallow. Height to 3m (10ft). Flowering period July-September.

Puccinia, which attacks cereal crops as well as mallows.

Dwarf mallow Slightly less familiar than the common mallow is the dwarf mallow. This species has a distribution similar to that of the common mallow and it occurs in similar habitats, though it is also found along coastal drift lines. In appearance the two plants are again similar, except that the dwarf mallow, as its name implies, is smaller. Its stem and leaves are more hairy than those of the common mallow, especially the trailing stem which is covered with downy hairs. The flowers are paler and less noticeable on the dwarf mallow than they are on the common mallow and the petals are narrower with deeply notched tips. The ends of the petals away from the notches bear small tufts of hair.

Musk mallow Britain's third native species of *Malva* is the musk mallow. This plant has the largest flowers among the British mallows – up to 6cm ($2\frac{1}{2}$in) across. Both the flowers and the crushed leaves have a delicate musky aroma.

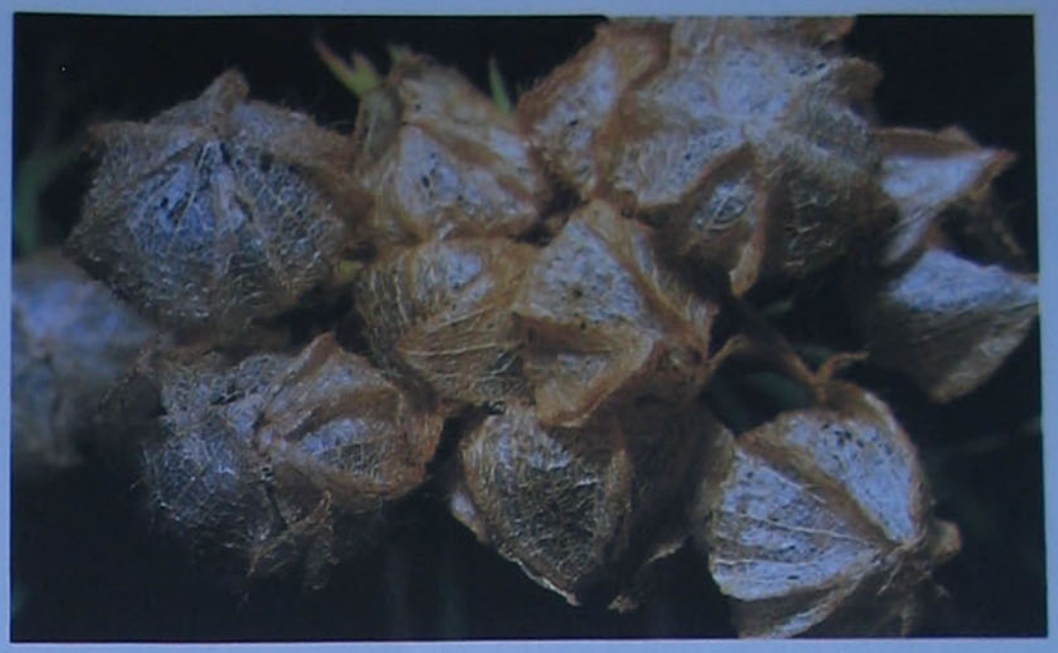
Musk mallow has a similar distribution in Britain to that of the dwarf mallow, except that it is rather less common in the north. It prefers more fertile soils than either the dwarf or the common mallows and is more likely to be found in grassy areas.

Marsh mallow Closely related to the true mallows, but belonging to the genus *Althaea*, is the marsh mallow. This is a perennial species growing to a height of 1.2m (4ft) with both stems and leaves covered in a dense velvety down. The flowers, which appear in late summer, are typically mallow-like.

Two other species of *Althaea* occur in Britain. The hispid mallow is a rare plant found on a few sites in southern England and the Channel Islands. A doubtful native, it is similar to the marsh mallow but smaller and noticeably bristly rather than velvety. The other species is the hollyhock, a familiar garden ornamental that often escapes and establishes itself in the wild.

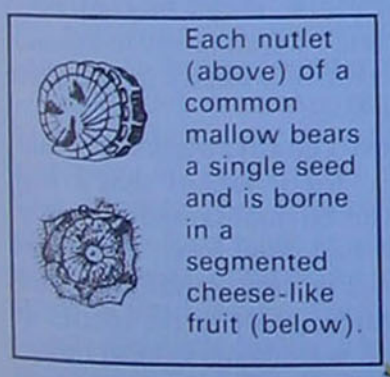
Tree mallows The most unusual British mallow is the tree mallow belonging to the genus *Lavatera* for, unlike the other mallows, which are all herbaceous, this species is shrubby – hence its name. In its leaves and flowers, however, the tree mallow is very similar to the other species.

The second species of tree mallow, the lesser tree mallow, is an annual or biennial herb and not at all tree-like. It is a rare plant, confined to Cornwall, the Scilly Islands and the Channel Islands.

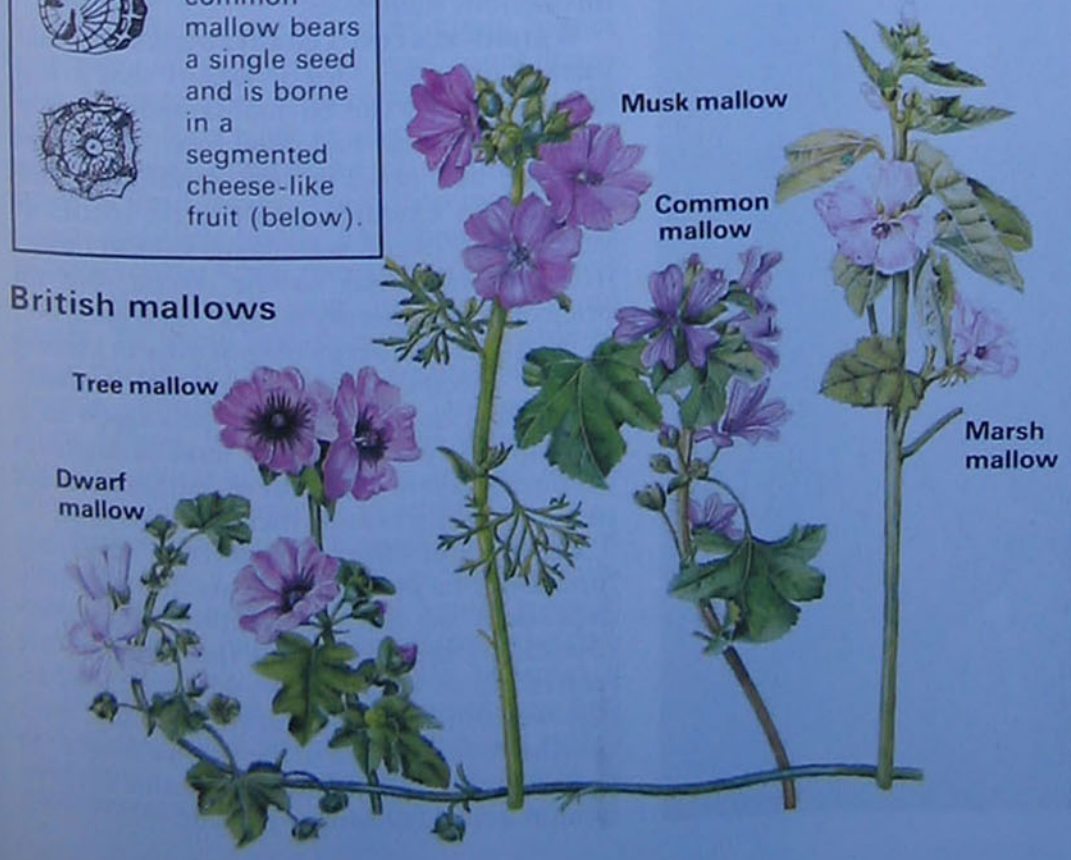


Above: The ripe fruits of musk mallow. All mallows have circular, somewhat flattened fruits divided into nutlets, each bearing a single seed – this arrangement is unique among British plants.

Below: All British mallows have very similar flowers consisting of five dark or pale pink petals with dark veins, surrounding a 'bottle-brush' arrangement of fused stamens. The flowers shown here are of the tree mallow. Note the large, three-lobed epicalyx, clearly visible just behind the flower buds.



Each nutlet (above) of a common mallow bears a single seed and is borne in a segmented cheese-like fruit (below).



British mallows

ON BEING COLD BLOODED

Reptiles, amphibians and fish are 'cold-blooded': unlike the birds and mammals, they depend directly on sunlight to maintain their bodily warmth.

As winter approaches we look out the woollen sweaters and other warm clothes which have been in store through the summer. Other mammals grow dense coats to combat the weather, and birds fluff out their feathers, so trapping a blanket of air which keeps the cold at bay. But mammals and birds are in a small minority, for the vast majority of species in the animal kingdom have no way of keeping warm in cold weather. They are described as cold-blooded animals.

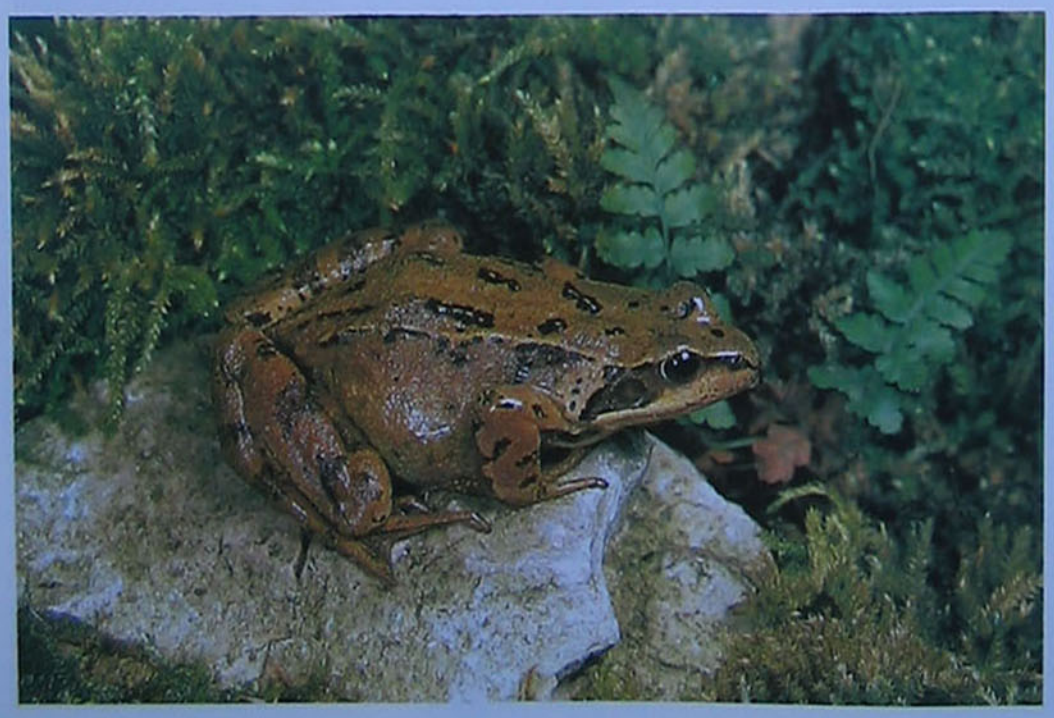
Here we look at the way of life of the cold-blooded vertebrates–fishes, reptiles and amphibians–and the contrasts between their way of life and that of mammals and birds. Insects, and the many thousands of other invertebrate species, are so different in many ways that a comparison with them would be an interesting, but quite different, subject.

A misnomer The term 'cold-blooded' is misleading, since it suggests that the body is in a state of perpetual chill. This is certainly not the case, for many cold-blooded animals can withstand high bodily temperatures. Even our own temperate-climate fauna provides an example of this, for common lizards can survive body temperatures far higher than the lethal body temperature for man.

A better word for cold-blooded animals is 'poikilothermic', which means having a variable body temperature: it can be contrasted with 'homiothermic', which refers to animals that maintain a relatively steady temperature throughout their lives.

Above: A female common lizard in the alert or hunting posture, though she is probably about to bask.

Below: A common frog shows the energy-saving method of hunting: it simply waits for prey to come near.



Warmth at a cost The advantages of homiothermy are great, for it means that a high level of activity can be maintained. A 'warm-blooded' animal can find food, breed and colonize new areas in cold conditions. Thus the fox, for example, is an active species all year round, over a wide geographical range–from tropical Asia to the Arctic. But the price of homiothermy is high, for a great part of the animal's energy output goes in keeping up its specific level of internal warmth. Homiotherms must find, eat and digest large amounts of food, and they have to maintain insulating layers of fat, fur or feathers in order to avoid losing heat to their environment.

Economy of effort By contrast, the bodily functions of a poikilotherm are almost totally dependent on the temperature of the surroundings: because of this these animals are referred to as 'ectotherms', which means outside-warmth animals. Not surprisingly, most ectotherms are found in the tropics, where the higher ambient temperatures enable them to remain active for longer periods.

In temperate regions (such as the British Isles), ectotherms become more active as spring begins. Lizards, snakes and frogs are able to increase their temperature by absorbing the sun's heat. They either do this directly, or by lying in a place that has already been warmed. Many lizards are in fact able to keep their temperatures within a very narrow range by adjusting their position or moving into the shade when they become hot.

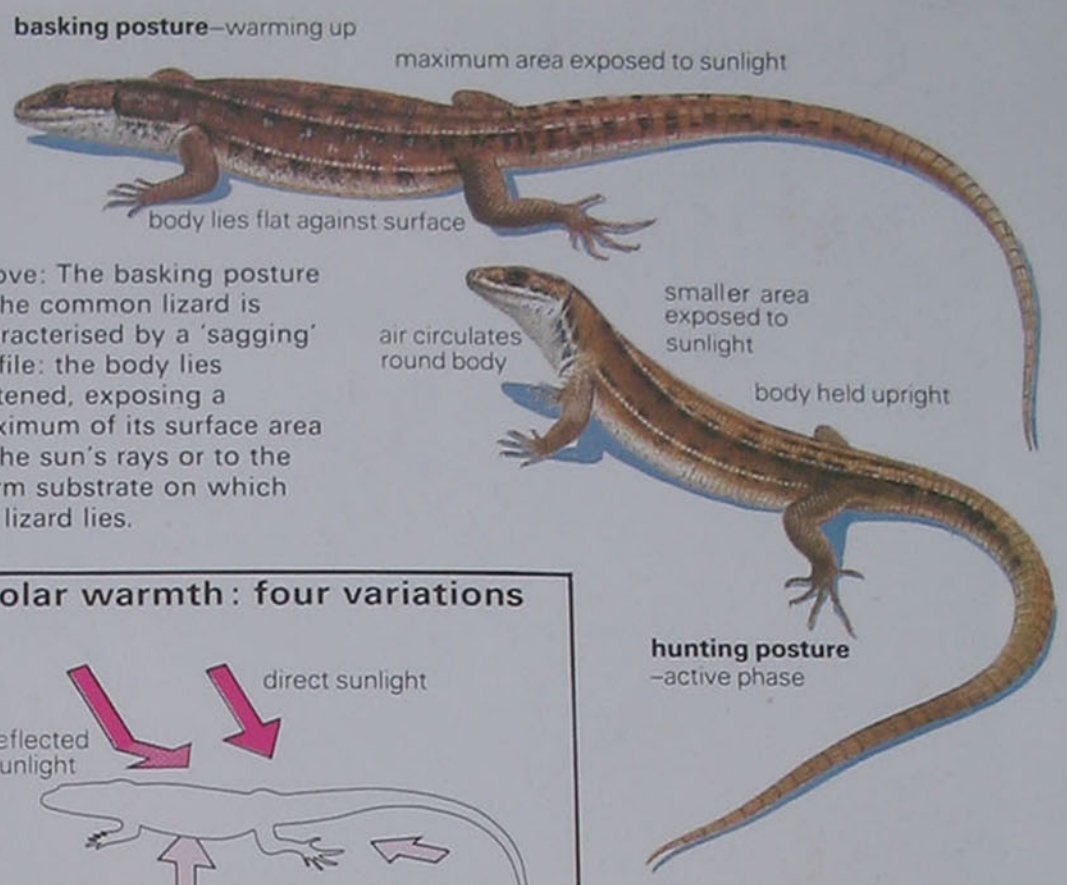
Having warmed themselves, the ectotherms are more able to move about. But it is unusual for them to move constantly. In general, reptiles and amphibians have developed feeding styles that do not rely on energetic pursuit of prey, for they cannot maintain a high output of energy for long enough to guarantee success. Instead, they rely on stealth, waiting motionless and unnoticed until a suitable victim unwittingly comes within range of a sudden, darting attack.

Temperate adaptations In many tropical species, the effect of ectothermy is that the animal is denied the possibility of living in the colder parts of the world. Yet certain species of ectotherm have succeeded in developing their minimum-energy mode of life so as to be able to survive in our cool temperate climate.

Unlike certain sea fishes, most of our freshwater fishes are unable to migrate to warmer places when winter begins. The tench is just one example of how freshwater fishes are adapted to survive winter. When a tench is cold, the chemical activity in its body is slowed down. It becomes sluggish and its respiratory and digestive processes may almost cease. The same is true of frogs, which simply lie in the mud during the winter months. But, provided the frost does not reach them, they do not die – they merely go into a resting state, consuming little food and awaiting an improvement in the weather.

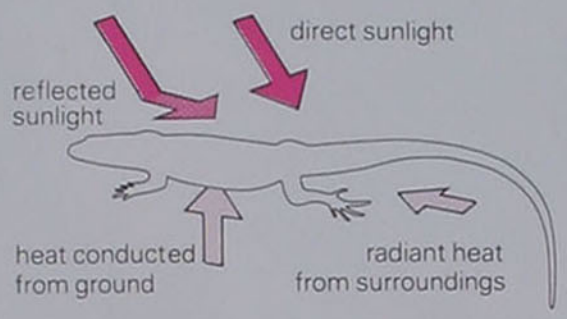
Hibernation is an extreme form of this behaviour. While some of our mammal species hibernate, all our reptiles and amphibians have adopted this stratagem. Lizards and snakes look for a place in which to rest for the winter months, often in the soil or under thick layers of dead leaves. They drop into a deep torpor and their bodily functions fall nearly to zero, so that when they emerge from their winter sleep, they have lost virtually no weight. In many instances they are able to begin the physically taxing process of reproduction almost immediately. This is sometimes helped by the habit of hibernating socially, which makes it easy to find mates when the animals emerge in spring.

Another temperate-climate adaptation is the small size of all our reptiles and amphibians. While there are also small tropical snakes, lizards and frogs, small size has a particular value in the temperate regions: it enables the animal to heat up quickly so that it may become active within minutes rather than hours, once the sun begins to warm its environment.



Above: The basking posture of the common lizard is characterised by a 'sagging' profile: the body lies flattened, exposing a maximum of its surface area to the sun's rays or to the warm substrate on which the lizard lies.

Solar warmth: four variations



The basking animal receives heat directly in the form of radiation; it also absorbs heat by conduction from the warm substrate; it receives reflected heat when the sun's rays rebound from a feature such as a rock; and it takes in thermal radiation which is given off by any physical body – such as a rock – particularly if it has recently been warmed by the sun.

Above: The alert posture of the common lizard: the animal has gained sufficient heat from the sun and is ready to hunt – or able to move rapidly away to escape danger. It holds itself upright, offering less of its surface area to the sun or the warm substrate.

A fourth adaptation to temperate conditions is that the females of many species are ovoviviparous. This means that they retain the fertilised eggs in their bodies, where they are protected and kept warm (for example by basking) until they are ready to hatch. The young break through the thin eggshell within seconds or minutes of their birth. Four out of the six reptile species native to the British Isles – the smooth snake, the adder, the slow worm and the common lizard – reproduce in this way.

Above: Three adders, disturbed in hibernation and still in the typical coiled posture. Hibernation during winter is one of the behavioural adaptations by which ectotherms are able to live in our cool temperate climate. The adaptation is also used in the Arctic environment – where hibernation lasts for eight months of the year.

REPRODUCTION IN BRITISH MAMMALS

Some mammal species produce up to seven litters annually, whereas others bear just one litter, and often only one offspring. Many are born blind, naked and totally dependent on their mothers for weeks, whereas some soon learn to cope alone.

Above: A British saddleback sow suckling her piglets. A well-nourished sow is able to breed when she is seven months old and has about 10 young in each litter. They take milk from their mother for up to eight weeks.

Like most other animals, mammals tend to give birth to their young when food resources and weather conditions are at their most favourable. In the British seasonal climate this is in summer, so it is not surprising that 80% of British mammal species concentrate their breeding activities particularly from April to September.

Ante-natal differences The gestation period (the period when the embryo develops inside the mother–usually from conception to birth) varies considerably between species. It is shortest in the small rodents and insectivores–from two to four weeks–and longest among some of the ungulates such as the red deer, where it may extend to eight months.

In some species there is a delay following the period of mating (when the sperm of the male is inserted into the oviduct of the female), and the development of a fertilised egg (embryo). This is called delayed fertilisation. In bats, for example, sperm may be stored over winter in both the male and female. If it is stored by the male it is then used during the mating season the following spring; if the male has already mated the previous autumn it may be stored in the female's uterus and oviduct, and a vaginal plug develops to prevent further copulation until the egg is fertilised after ovulation. This usually occurs about seven weeks before birth, but it varies between species. In the little pipistrelle it is six weeks, whereas in the larger noctule it is

ten weeks.

Other British mammals show a variant of this process known as delayed implantation. Here the egg is fertilised but remains free in the uterus and does not develop until it is implanted in the uterus wall. The period of delayed implantation is usually quite long (as much as 10 months in the stoat), or variable (3-9 months as in the badger). Normally it is around 3-5 months, as in, for example, the grey and common seals, pine marten and roe deer. This delay in gestation means that both mating and birth can occur at convenient times of the year, irrespective of the length of gestation. It generally occurs in species with single litters each year, and may have evolved when ancestors of present-day forms found it disadvantageous to bear multiple litters each year.

The length of gestation dictates the number of litters a mammal may have each year. If it is just two to four weeks and conditions remain favourable, a female can have many litters successively in one season. A rabbit, for example, can have up to seven litters, each comprising up to seven young (as the season progresses the size of litter tends to get smaller). Young rabbits become pregnant within about four months of birth. On the other hand a red deer, or the grey or common seals, have just one offspring annually, while the sperm whale bears a single offspring only once every three years.

Embryo failure Although one or more matings may result in a number of developing embryos, it is common for a proportion of these to fail. The timing of this mortality varies according to species. In the mole, with an average of four embryos, 6-20% of the embryos may be re-absorbed, probably depending on the body condition of the female. If feeding conditions are poor, more embryos may be re-absorbed, or abort, than if the female finds plenty of food. In the hedgehog the loss of embryos before birth is usually small (less than three per cent) but about 20% of young may die before weaning.

Other environmental conditions besides food availability may result in loss of embryos. In the rabbit, for example, mortality may involve entire sets of embryos and if the population is breeding at high densities up to 60% of litters may be lost in this way, presumably the result of increased stress under crowded conditions.

Post-natal care Mammals differ from most other animals in that the young are fed on milk secreted by the mammary glands. This means the mother must spend at least some time with her young, and for their part the young are dependent upon her at least for a period until they are weaned, but often for longer than this. Maternal care, however, usually also involves the mother in protecting, cleaning and keeping warm her young, and in some cases the mother plays an active part in introducing them to solid foods.

When the young are born they must either be sufficiently advanced to be capable immediately of independent movement and of keeping warm by bearing fur (precocial) or, if they are more or less naked and blind (altricial), they must be protected in some form of nest or refuge. In the British Isles almost all species in the former group are ungulates (deer and goats) or pinnipeds (grey and common seals) or whales. The two hare species are exceptions which contrast with the closely related rabbit in being born fully furred in a scrape (form).

All precocial young are born furred and with functional eyes and ears, but they may vary in their ability to follow their parents. Some, such as whales and dolphins, immediately follow their mother, initially rarely being separated from her. Most, however, spend much of their time resting in the one spot where immobility and cryptic coloration

Above: The young of the rare mouse-eared bat, and (below) a roe deer fawn. In some mammals, such as bats, delayed fertilisation occurs when the sperm may be stored over winter in the male or female. Other British mammals have a period of delayed implantation when the egg is fertilised and does not become implanted in the uterus wall or start to develop for several months—about three to five months in the case of the roe deer. This is a relatively uncommon process, although it occurs across a variety of mammal families.

Left: A wood mouse suckling her young in the underground nest. Wood mice have litters of five to six young from March to November, depending on the availability of food. They develop their juvenile coats after about a week, their eyes open at about two weeks, and they are weaned after about 18 days.

reduce their chances of being discovered by a predator. Thus the young of deer and hares spend their first few days (usually up to ten days) concealed among vegetation where potential predators have great difficulty in finding them.

Although the fawn chooses the lying-out place, the mother dictates the feeding time. She may call as she approaches and adopt a characteristic posture. After a mutual nose-sniffing session the mother may lick the rear of her young, who then starts to suckle at her udder. As it grows, the fawn spends less time lying-out alone and starts to follow its mother.

Most species with precocial young have small litters of either one (deer, seals, whales) or two or three (hares). Those with altricial young generally have much larger litters. In small rodents such as mice and voles, in insectivores such as shrews, in small mustelids such as weasels and stoats, and in rabbits, there are generally four to eight young in a litter. In larger carnivores, such as the pine marten, badger and fox, and in squirrels, there are three to five in a litter. Bats are rather unusual in having a single young born blind and either hairless or with only sparse fur. It clings to its mother for much of the first few weeks. She rarely flies with her young unless disturbed, but when she is feeding she will leave it for periods in a nursery crêche after it is about one week old.

For those mammals which bear blind and helpless young a refuge must be found–a cave, the roof of a building or a hollow tree, or–more usually–a nest or den. All small rodents, such as mice, rats and voles, build

Below: Carnivorous mammals (the hunters) deposit their young either below ground in a burrow, as do the fox and badger, or above ground in a den among rocks or the roots of a tree, as do the pine marten, stoat, otter and wildcat–and the polecat, the growing young of which are shown here.

Shelters for mammal young

nests which may comprise leaves and grass or even paper, string and other man-made destructable materials. Some species, such as the water vole and wood mouse, generally build a nest below ground; others, such as the common dormouse and harvest mouse, construct a ball of grass or leaves at the base of vegetation or slung from grass or reed stems. The mother rabbit builds her nest of grass or moss underground in a small burrow or a side-branch of the warren itself and, during the two days before she gives birth, lines it with fur from her belly.

Once born, the young are initially constantly attended by their mother who provides food in the form of milk, and warmth. In most species she remains with her young for the first 24 hours but then makes forays out to obtain food for herself. Some species spend more time with their young than others. Thus, for example, a vixen fox remains in attendance all day and most of the night for the first three weeks of her cubs' lives. The rabbit, however, visits her young only once nightly and suckles for about five minutes only. When the young are alone they keep warm by huddling together. If a nest is disturbed, the mother often picks up the young one by one (usually by the scruff of the neck) and takes them elsewhere. She may then have to build another nest or, as in the case of the red and grey squirrels, an alternative nest is generally available and simply requires lining with soft fur and moss.

Growing up As the young develop and their eyes and ears open they become more responsive to objects other than their mother. Smell probably plays an important part in the mother-infant bond, although high-pitched squeaks or squeals, sometimes in the ultrasonic range, may also summon the parent in case of distress. An intruder – a potential predator or a member of the same species – is driven off aggressively by the mother and in the case of some carnivores, notably the wild cat, the young may also react by hissing or spitting.

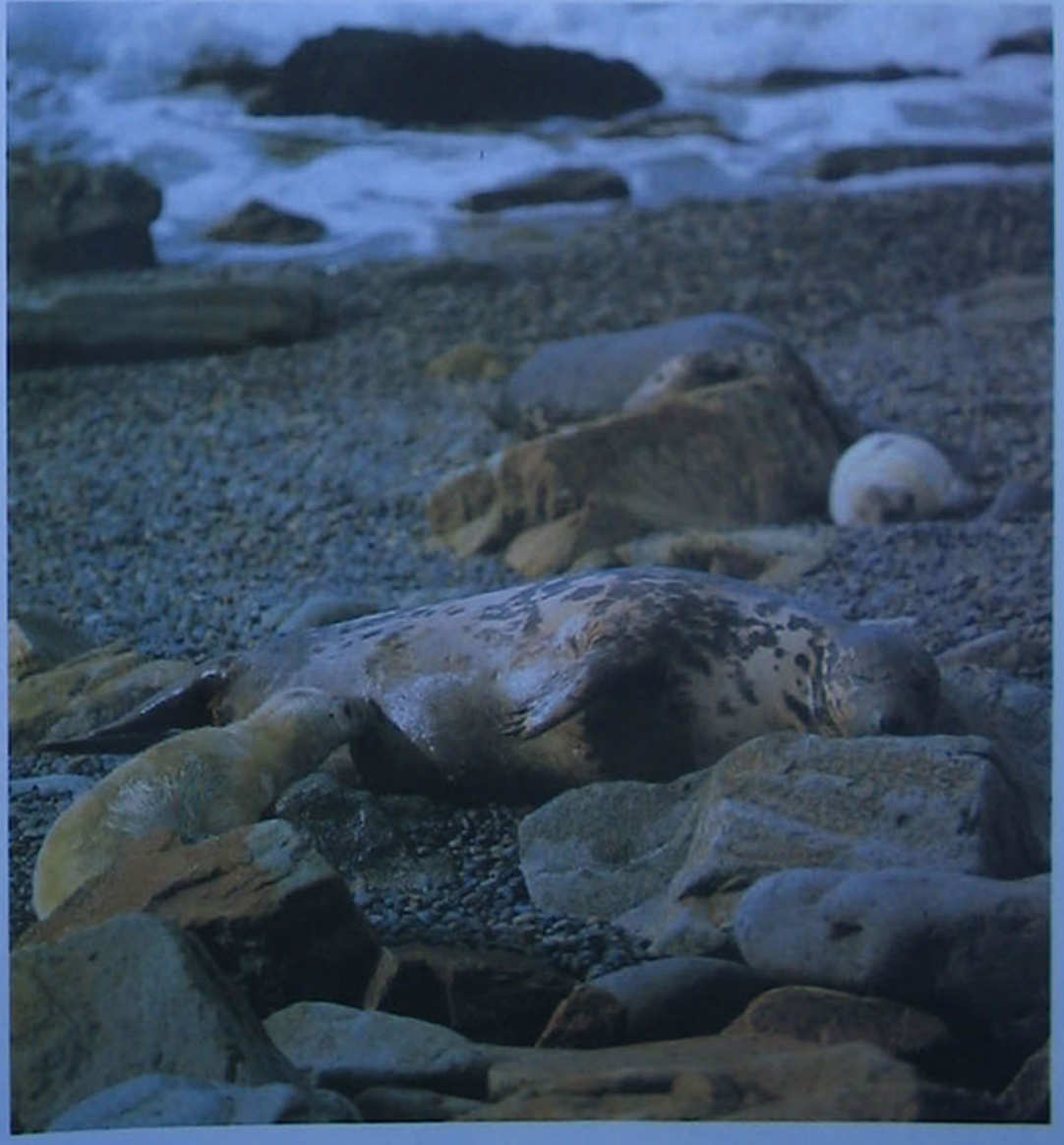
Although the young of precocial species (deer and hares) continue to suckle for a long period – sometimes up to a year – despite their rapid ability to feed themselves, they do feed on either items as well. Altricial young, however, depend entirely upon their mother's milk for most of the lactation period. This period may be as short as two or three weeks, as in most mice and voles, or two or three months, as in most carnivores (four months in the wild cat).

In most rodents the young become independent soon after weaning, but for carnivorous species there is a slow transition to solid foods which at first are brought to the nest by the mother and may be partially digested by her. Later, usually slightly before weaning, the young start to make their own forays from the nest accompanied by their mother who may then capture prey in their presence. The young play a great deal with each other and practise capturing food. If they lose contact with their mother they generally call anxiously and she returns immediately. As they become increasingly independent, she in turn becomes more aggressive towards them and finally, just before she gives birth to the next litter, the parent-offspring bond is broken, and the young begin to live lives of their own.

Although the bond is broken for most mammals at this stage, in some of the social carnivores – notably the badger – the young may remain in the same social group as their mother for several years and may rear their offspring with her subsequent litters.

Above: A rabbit doe lying across the nursery hole of the burrow while her young feed. Baby rabbits are born 28 days after the eggs have been fertilised; they do not go out from the nest until they are about 18 days old.

Below: A grey seal cow suckling her very young pup. An older pup with its mother is further down the beach. Seal pups are precocial – capable of independent movement and of keeping warm from birth.



BUDDLEIA: BUTTERFLY BUSH

Less than a century ago no British naturalist had heard of buddleia. Yet today it grows all over Britain, in both gardens and the wild.

Throughout the world there are more than a hundred species of buddleia. They are native to North and South America, southern and eastern Africa and parts of southern Asia, but none is native to Europe. Even so, a number of species have been introduced into British gardens and one has become naturalised here. This is *Buddleia davidii*, the butterfly bush, known in its native China as 'summer lilac'.

The Latin name is derived from the names of two men: Adam Buddle, a 17th century English naturalist, and Père David, a French missionary who discovered the bush in the hills of central China in 1869. (Père David also gave his name to other Chinese wildlife, such as Père David's deer and Père David's maple.)

Butterfly bushes – or buddleias as they are often called – first appeared in Britain in 1890 but they were poor specimens, imported via Russia. By 1898, however, better stock had been received. In the early 1900s, many more bushes were imported into Britain from central China, and most of our naturalised and cultivated buddleias are descended from this stock.

Buddleia structure The butterfly bush is a deciduous or semi-deciduous shrub which may grow to a height of 5m (16ft), though it can bear flowers when it is less than 1m (3ft) tall. Its long, narrow leaves are grey-green, with numerous downy hairs on their undersides that make them look almost white. These hairs, which surround the leaf pores, help to prevent the wind from drying out the leaves. They are an adaptation to conditions in high, exposed areas such as the hills of the plant's native China.

Buddleia flowers are extremely small – no more than a few millimetres across – but they are clustered together in huge numbers on spikes up to 40cm (16in) long. In their naturalised state, buddleias have pale blue flowers, but on garden varieties the flowers can vary from white to lilac, reddish or dark purple.

The clustering of the flowers on the spikes serves to heighten their colour, making them more obvious to insects such as butterflies. The spikes also concentrate the powerful scent of the flowers. This combination of colour and scent attracts many different species of butterfly to feed upon the nectar. The nectar of a buddleia flower is not remarkably different from that of other flowers, yet it attracts butterflies and other insects in greater numbers than almost any other bush.

Garden escape Although it is a recent introduction to the British Isles, buddleia has already found a permanent place in our towns

Above: A naturalised buddleia in flower. The spikes of flowers may appear any time from June to October. After the flowers die, the spikes may stay on the bush for much of the winter.

Below: Small tortoiseshell butterfly on buddleia.

and countryside. It has been planted in gardens all over Britain and Ireland, from where it has spread into the wild via its winged seeds. Buddleia seeds resemble tiny propellers. Once the flowers have died the ripening seeds grow pointing upwards (an unusual phenomenon known as negative geotropism). The seed-cases split at maturity and the wind blows the seeds away from the parent plant.

If these seeds fall among grass or herbaceous plants they seldom germinate. Instead, they seem to prefer to fall on stony ground, for instance among dry rubble, in walls or along railway embankments.

Population explosion Naturalists began to notice buddleias growing wild in the countryside only 30 years after their introduction to this country. Limestone quarries, crumbling walls and areas of bare chalk – all exposed areas with high levels of calcium – were soon recognised as places to see 'escaped' buddleias.

Following World War II the buddleia underwent a population explosion. Every bomb site and building site represented an ideal situation in which the buddleia could flourish and, in just three or four years, some derelict sites became covered over with a dense tangle of these bushes. (One of the early explorers of China noted that buddleia thickets provided 'famous harbourage for leopards'.) Today, in London and other towns and cities any demolition site not immediately built upon becomes a nursery for buddleias.

Introduced plants that spread quickly often displace native plants and therefore disturb the balance between plants and animals in the countryside. But this is not the case with buddleia. It seems to have occupied an ecological niche that was vacant.

Buddleia for food Since buddleias are not native to Britain – nor indeed to any part of Europe – our own native fauna might well have found them unpalatable. The reason for this is that plants evolve in association with the insects of their native land; in a new environment with different insects an introduced plant might take a long time to develop an associated fauna. Buddleias, however, seem to be an exception to this rule.

Several different parts of the buddleia are eaten by British insects. The nectar attracts both common and less familiar butterflies, from the cabbage whites to the silver-washed fritillary, as well as hoverflies. The caterpillars of more than ten species of moth have been recorded on buddleia, most being leaf-chewers.

Most of these feeders eat a variety of different plants, but a few feed on only one other family of plants – the Scrophulariaceae, which includes figworts and mulleins. (Buddleias are classified as a separate family, the Buddleiaceae.) This suggests some sort of chemical similarity between buddleias and members of the Scrophulariaceae, which may help to explain how so many British insects have been able to switch to buddleias as a food source.

In the wake of these feeders have come the predators, such as spiders and ladybirds. So it seems that a complicated food chain is forming – only 90 years after buddleia was first introduced into Britain.

Garden buddleias

The parent species, *Buddleia davidii*, has given rise to several garden varieties with different colour flowers. These varieties are all sterile and cannot, therefore, escape to the wild; they are only seen in gardens. Some of the most popular are: 'Black Knight', which bears heads of deep violet-purple flowers; 'White Cloud' and 'White Profusion', which are white-flowered varieties; and 'Harlequin' and 'Royal Red', both with red flowers, the former having leaves variegated with white.

Feeders on buddleia

Some of the many insects that feed on buddleia at different times of the year. Butterflies feeding on nectar include: (**1**) peacock (*Inachis io*), (**2**) small tortoiseshell (*Aglais urticae*), (**3**) red admiral (*Vanessa atalanta*) and (**4**) large white (*Pieris brassicae*). Among the leaf-feeders are caterpillars of such moths as: (**5**) vapourer moth (*Orgyia antiqua*), (**6**) dot moth (*Melanchra persicariae*), (**7**) mullein moth (*Cucullia verbasci*) and (**8**) scalloped hazel (*Odontopera bidentata*); (**9**) the meadow spittle bug (*Philaenus spumarius*) and (**10**) the weevil *Conius hortulanus*.

BEE-LIKE DRONE-FLIES

Drone-flies, a kind of hoverfly, are found on garden flowers in summer, although their larvae thrive in less pleasant surroundings – water-logged crevices in rotting wood, manure-fouled water, and even the fluids that exude from decaying carcases.

Above: *Myiatropa florea*, at 14-15mm ($\frac{1}{2}$in) long, is one of our larger hoverflies. The attractively marked female lays her eggs – which later develop into aquatic rat-tailed maggots – in tree-holes filled with stagnant water, cavities in surface roots, or saturated rotting wood.

If you look closely at garden flowers in summer, and particularly at Michaelmas daisies in autumn, you are bound to come across some fairly large brown flies which, at a quick glance, resemble honey bees. They are in fact a kind of hoverfly, popularly known as drone-flies because of their resemblance to male honey bees, a similarity which is heightened by the buzzing noise they make if you pick one up.

Maggots with a tail Female drone-flies lay groups of up to 20 eggs in crevices around the edges of foul water. The eggs, which are white and cigar-shaped, hatch after a few days into whitish larvae equipped with telescopic tails, which have earned them the name of 'rat-tailed maggots'. Each tail has two breathing tubes (tracheae) running along its length, ending in a single ring of five feathered water-repellent hairs that enables the tip to adhere to the water surface. At the other end of the tail the tracheae expand into the larva's body in larger tubes and air sacs which are silvery in appearance and help to store air. This tail is immensely extensible and can reach the water surface from depths of up to 15cm (6in), at which time its diameter becomes no thicker than a stout thread.

Swimming larva Like all true fly larvae, the rat-tailed maggot is legless, although it has developed seven pairs of short foot-like lobes armed with fine hooks which help it to move around. Besides creeping along the bottom of the pool, the rat-tailed maggot swims in a snake-like manner, contracting its tail (the breathing tubes coil up at the base of the tail) so that it loses contact with the atmospheric air.

The larva takes a month to become fully grown (reaching about 2.5cm/1in long, excluding the tail), moulting twice in this period. It then leaves the water and burrows into the damp soil, the soil particles adhering to the sticky secretions on its skin. As with all the more highly evolved flies, the larval skin hardens and acts as a cocoon or puparium for the pupa, which remains inside. After one to three weeks the old larval skin splits and the adult finally emerges.

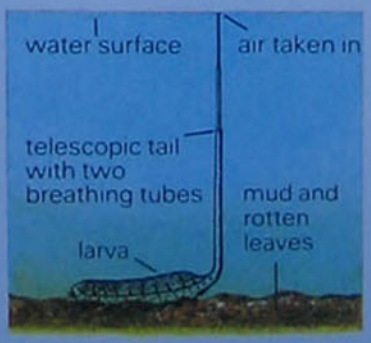
Drone-flies There are several related species of drone-fly, but the true drone-fly, *Eristalis tenax*, at 15mm ($\frac{1}{2}$in) long, is the commonest. It is abundant on all kinds of flowers in gardens from April until September, when it goes into hibernation in sheltered places.

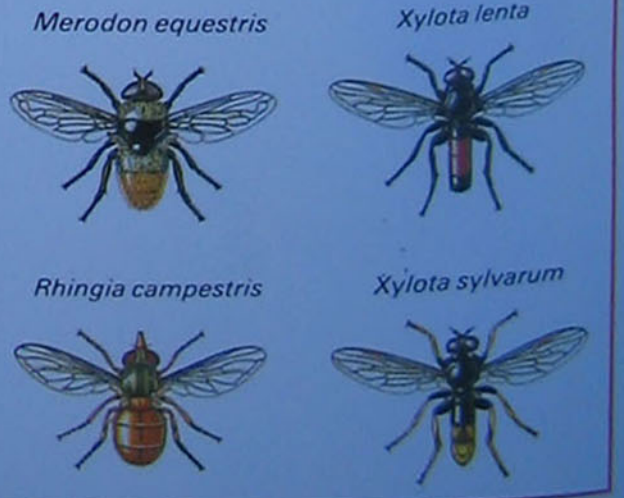
Helophilus pendulus is related to *Eristalis tenax*. It is 12-14mm ($\frac{1}{2}$in) long and is attractively marked in black and yellow with four longitudinal stripes on its thorax. It is common on such flowers as umbellifers and ragwort, and is frequently seen on foliage around garden ponds. The female lays her eggs in stagnant or particularly foul water, where they hatch into larvae which, in appearance, are remarkably similar to those of *Eristalis tenax*.

Another common hoverfly with rat-tailed larvae is *Myiatropa florea*. It is slightly larger than *H. pendulus*, measuring 14-15mm ($\frac{1}{2}$in) long, and has a similarly marked abdomen but lacks the thoracic stripes. Its eggs are placed in water-filled cavities in trees, or similar holes in surface roots, and in saturated, decaying wood.

Bulb flies The large bulb fly (*Merodon equestris*), 13-15mm ($\frac{1}{2}$in) long, is not unlike species of *Eristalis* at first sight, although it is

Below: The aquatic drone-fly larva – a rat-tailed maggot – takes in air through its telescopic tail.





hairier and shows a closer resemblance to a small bumble bee than to a honey bee. Its colour may vary considerably, from the tawny-haired specimens to the darker flies with buff or even reddish-haired tails. One particularly common form has a yellowish band across the front of its thorax, a reddish tail, and a black saddle on the centre of its thorax – hence its Latin name *equestris*.

All these forms of large bulb fly interbreed quite freely and can be found in the same garden; it is interesting that so many bumble bee-type patterns are produced by the one species.

The large bulb fly is often regarded by gardeners and commercial growers as a serious pest. Although it is mainly a pest of narcissi, there are records of this species also attacking onions. Before mating the male hovers over the female, and then rises and falls above her for a few minutes before coupling and mating in the vegetation. The female lays her eggs, usually numbering about 40, in June and July, placing them singly on the dying leaves or on the neck of the bulb – she reaches this by crawling down the hole left by the dead leaves.

On hatching, the young larva crawls down the outside of the bulb and burrows into the base; there is usually only one larva per bulb. The larva stays in the base of the bulb for a time and then works its way into the bulb's fleshy leaves where it stays, eating out a large cavity in the centre. Here it remains until the following spring when, as a fully grown larva 18mm ($\frac{3}{4}$in) long, it leaves the bulb and pupates in the soil, remaining as a pupa for about six weeks. Although the bulb may not be killed, it is unlikely to flower and is usually worthless.

Xylota lenta, a less common hoverfly, is on the wing from May to September. It visits only white flowers, and is easily identified by the deep red band on its abdomen and its black legs. *Xylota sylvarum* is even larger, at 15mm ($\frac{1}{2}$in) long, and has a golden-haired tail. Both these hoverflies are quite common in woodland, where they sit on flowers and bask in the sun; they are frequently seen in gardens as well. Their larvae feed in the rotting cavities of trees and logs.

Fly with a snout Most people have seen the curious looking *Rhingia campestris*; it is 10-13mm ($\frac{1}{2}$in) long, and has a chestnut brown abdomen and extended snout. This species is unusual in having a long, stiff proboscis which allows it to feed deep down in flowers such as *Convolvulus*; the snout protects the proboscis when it is not in use.

Rhingia campestris is common on flowers and vegetation around meadows and woods, particularly where cows are grazing. The female lays her eggs on grass and low plants close to dung-pats so that the larvae – which have short tails – can drop or crawl on to the dung to feed and eventually pupate.

Above: Species of *Eristalis* were mistakenly thought to be bees in the past, and were referred to as 'oxen-borne bees' in ancient literature, as they breed in the fluids which ooze from rotting carcases.

Below left: The hoverfly *Eristalis tenax*, feeding on ragwort. This species is abundant from April to September in gardens.

Below right: A pair of *Helophilus pendulus* hoverflies mating on bracken.

THE RICH LIFE OF LOWLAND LAKES

Lowland lakes – such as those in Shropshire and Cheshire – differ markedly from those of the Lake District in being nutrient-rich and therefore very productive. Algae in abundance are characteristic of lowland meres and proliferate in early summer.

Below: A mass of yellow flag irises growing along the margins of a small lake. Most lowland lakes have muddy bottoms and are surrounded by soil (rather than by rock); consequently yellow flag and other emergent species, such as reedmace and bulrush, flourish along the edges.

Lakes have been formed in a variety of ways, but what interests the naturalist is the shape of the resulting basin and its location. The Cheshire-Shropshire plain once lay under a sheet of ice that brought with it soil and boulders scraped from the land as it advanced. When the ice melted it left behind hollows that filled with water, thus forming the meres that still exist today. Many – Crose Mere is one – are typical lowland lakes. They are shallow, for the ice did not excavate deeply, and are not much longer than they are broad. They lie in small drainage areas in a thick layer of soil, now fertile agricultural land, and consequently rain reaches them mainly by seepage, bringing a rich supply of nutrients.

When the rain is heavy in these areas it does not come as a flood, diluting the lake and its inhabitants. This contrasts with the Lake District, where the ice, concentrated by the valleys, gouged long, deep, narrow trenches lying in large rocky drainage areas. Rain dissolves little from the thin superficial soil and, when heavy, may enter the resulting lakes in such volume that a significant portion of the open water inhabitants are carried through to the outflow.

Similar lakes or meres have been formed in other ways, such as by damming, subsidence or human excavation. One example of the latter is the Norfolk Broads – created by digging for peat in medieval times.

Marginal zones versus open water Parts of the margin of a mere may be so exposed that waves erode the bottom and remove all but stones, but most mere edges are, in fact, covered by soil in which grow emergent

plants – reed, reedmace, bulrush, yellow flag and others. Beyond them there is a zone of water-lilies and, in deeper water, various pondweeds and other submerged plants which, however, do not extend far as there is insufficient light. Large numbers of a variety of animal species find food and shelter among this vegetation.

In the open water there is a good supply of such nutrients as nitrates and phosphates, and the production of living matter is prolific. Plant activity is limited to the surface layers because the sun's rays do not penetrate far, even into pure water; and when many organisms crowd the surface, the sun's rays hardly penetrate at all.

There is no anchorage for plants in open water and no plant can keep its place from year to year, as does a reed at the lake edge, for example, with its roots in the mud ready to put forth new shoots in the spring before any competitor starting from seed can take its place. Furthermore, there is no cover to provide shelter for animals from predators, whose activities can be countered only by rapid reproduction.

Only small plants and animals, therefore, can inhabit the open water environment. The plants here are all algae, small to minute in size, often consisting of a single cell, and capable of reproducing by simple division. Among these algae there is a seasonal succession throughout the year, different species attaining great abundance by rapid, often asexual, reproduction and then declining to survive in small numbers or in a resting stage.

Seasonal changes in a mere The changing conditions, favouring first one species and then another, are produced by sun and wind and by the activities of the organisms themselves. The seasonal cycle of the mere begins when the sun warms the upper layers of the water, producing in still weather a sharp gradient, for water warmer than 4°C (39°F) floats on top of colder water. Wind mixes the layers and also sets up vertical turbulence, but after a time a body of warmer water several metres deep is created and remains separate from a lower, colder layer all through the summer. This occurs in all the deeper meres.

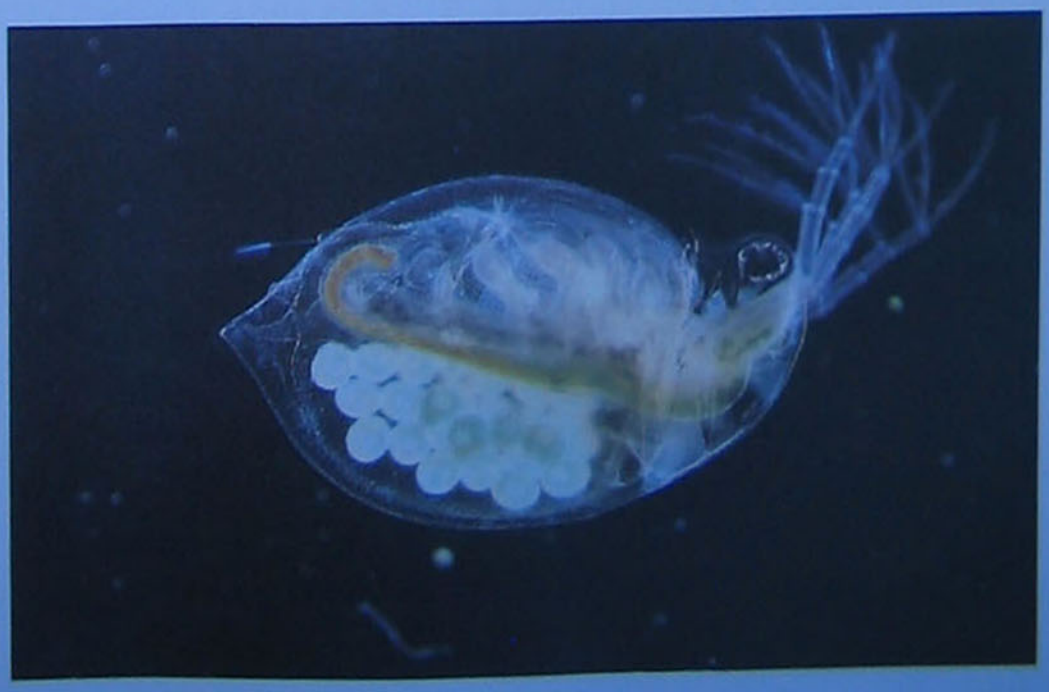
The copious production of living matter in the upper layers leads to a rain of dead and dying organisms falling to the bottom. Bottom-dwelling animals and bacteria exploit this food supply. They use oxygen in the process and, if the volume of the lower layer is relatively small, they may deplete it of oxygen, in which state it remains until the water layers mix in the autumn. Lakes where this occurs are termed 'eutrophic'.

Algae and algal bloom The first algae to start rapid reproduction as the sun gains strength in spring belong to a group known as diatoms; they are characterised by a shell made of silica and a lack of swimming organs. The turbulence of the water keeps them in the light but, during a calm, still spell, they may

Above: Algal bloom on Crose Mere in Shropshire. The appearance of blue-green algae in the form of scum on the surface of the lake is called 'the breaking of the meres' and occurs regularly as the community ages.

Right: The larva of the alderfly *Sialis lutaria* – one of many carnivores found in lowland meres.

Below: A water flea with eggs in its brood pouch. Creatures of this type belong to the zooplankton – the animals floating in the open water of lakes.



sink, bringing their activity to an end. If the weather remains windy, however, they may exhaust the supply of silica for making their shells, after which only a small population survives until conditions are favourable again.

Their place is taken by quite different groups of algae which, provided with small lashing organs for movement, can devote some of the available energy not to reproduction but to moving through the water in search of favourable conditions. By this time a short windless spell can result in a dense algal population near the surface, with consequent shallow penetration of the sun's rays and depletion of nutrients. Therefore, the ability to move between lower zones, where nutrients are still to be found, and upper ones in the sunlight, is a great advantage. The proliferation of algae is followed by a proliferation of animals which feed on them–a further factor altering the composition of the community.

Blue-green algae, typical of productive lakes in late summer, can regulate their buoyancy by means of gas vacuoles–probably a more economical way of moving up and down than swimming. As the population ages, the control of gas formation breaks down; too much is produced and the algae come to the surface to form a green scum, a familiar phenomenon known as the 'breaking of the meres' or 'algal bloom'. The scum eventually drifts ashore and decomposes.

Animals of open water The zooplankton (the animals floating in the open water) is composed mainly of small crustaceans such as water-fleas, and rotifers or wheel-animalcules. Many increase rapidly in numbers by asexual reproduction when conditions are favourable which, for most, is when small algae and bacteria are abundant.

The first flush of herbivorous species is followed by an outburst of carnivores. One such is the phantom larve *Chaoborus*, which gives rise to a fly related to the mosquito. It is the only planktonic insect and is transparent except for two gas-filled bladders whereby, without too great an expenditure of energy, it can seek refuge in the mud by day and rise to seek its prey by night.

Fauna of the mud The mud that covers much of the bottom of a lake provides both cover and food for animals that are adapted to burrow into it. These specialists comprise the nymphs of the mayflies *Ephemera* and *Caenis*, larvae of the alderfly *Sialis* and the larvae of chironomids, pea mussels and worms. Only the last three groups are found in the deep region, where oxygen is scarce in summer.

Chironomids, of which there are some 400 British species, occur in every type of aquatic environment and, in productive waters, give rise to enormous numbers of adult non-biting midges.

Fauna of the vegetation In the vegetation animals are abundant; many species feed on each other, on algae attached to the surfaces of plants, or on decaying vegetation. Beetles and some bugs, aquatic throughout life, are active hunters, and leeches too catch prey. Flatworms lay down a sticky mucous trail in which prey becomes entangled. Dragonfly nymphs and both stages of some bugs (the water scorpion *Nepa*, for example) lie in wait for their prey and seize anything which comes in reach.

The larger crustaceans, such as the freshwater shrimp *Gammarus* and the hoglouse *Asellus*, feed predominantly on detritus and plants, although *Gammarus* is occasionally seen with living prey in its claws.

Fishes and birds Among the fishes, which can range through the open water of lakes, and penetrate the vegetation where it is not too thick, are perch, pike, carp, roach and eels. Trout are recorded from a few meres.

The meres are noted as haunts of the Canada goose and the great crested grebe, as well as for the various species that frequent reedbeds–the reed bunting, for example. Many kinds of duck, together with the coot and moorhen, can also be seen on the meres.

Above: *Sympetrum flaveolum*, a particularly striking dragonfly, is a frequent migrant from the Continent and favours meres with rushy margins, mainly those in the southern counties.

Opposite page: The lowland lake at Castor Hanglands near Peterborough is one of the most beautiful in England.

Below: Pike usually stay close to the banks of meres where weeds are dense, but may stray into deeper water in large lakes. From an early age they feed on other fishes and also prey on waterfowl, small aquatic mammals and even each other. They can grow up to 1.3m (4ft) long.

Above: A pair of greenfinches (the male is on the right) with four young. In the past, these birds were often caught and caged—such birds used to be called 'green linnets'.

GARDEN VISITING GREENFINCHES

The greenfinch is the largest of a trio of British finches with partly green plumage (the others are the siskin and the rare serin). It is one of our more numerous birds, being well suited to our lowland countryside with its mosaic-like pattern of woods, farmland, hedgerows, thickets and gardens.

Below: A male greenfinch (right) with a juvenile (left) at water. The juveniles are much less highly coloured than the adults. Many have brown streaks on their plumage, like sparrows.

The greenfinch is one of the most widespread and abundant visitors to bird-tables in Britain and Ireland. It is sometimes disparaged by birdwatchers who are captivated by the acrobatic feats of the blue and great tits as they hang on to strings of nuts. The greenfinch, being a relatively large finch, is not a particularly acrobatic feeder although, in many areas, it has learned to feed on hanging nuts. Some people actually overlook its presence since it is similar in size to the ubiquitous house sparrow, and many greenfinches have rather little yellow or green on their plumage, which strengthens the resemblance.

The adult male greenfinch is a handsome bird, with brilliant yellow flashes on the wings and tail—most obvious when in flight—and washes of green and greenish yellow over the rest of the plumage. The females, and the young of either sex, are less highly coloured, with much brown streaked plumage—like a sparrow's. (In recent years another much smaller finch, the siskin, has also taken to

feeding in gardens, mostly at the end of winter, but there is little chance of the two being confused.)

Habitat and range As with many of our garden and farmland bird species, greenfinches are naturally birds of the woodland edge, finding hedges in arable land, and shrubberies in parks and gardens, ideal places for breeding. They can be found over most of Europe, spreading into Asia in the east and to north Africa in the south, but they are absent from the far northern parts of Europe and Asia, which lack trees or shrubs. Many areas in Britain have reported recent spreads in the breeding range and local increases in numbers.

Seed eaters Greenfinches feed on seeds for almost all their lives. In the autumn the flocks of young birds, which are soon joined by the adults, may become very numerous, with some numbering in the thousands. These large flocks are sometimes seen feeding on ripening corn, gleaning the stubbles or feasting on weed seeds in root crops or on waste ground. Their weight generally precludes feeding from seeds still held on the plants, but they are adept at finding seeds on the ground. They can live well on open ploughed land, finding dormant seeds which may, in some cases, be several years old.

The weeds particularly favoured include charlock, persicaria, groundsel, chickweed and fat hen. When a large flock has found a good feeding site, it is quite possible to hear the birds from thirty or forty yards away – not from their calls but from the cracking of seeds in their bills. All the food is first manoeuvred in the bird's beak to remove the husk, for greenfinches only eat the central nutritious part.

Autumn and winter The autumn flocks frequently contain other finch species, but during the evening the greenfinches tend to roost on their own. The roosting site is often a clump of rhododendrons, laurels or an old hedge with plenty of holly or ivy. The birds prefer roosting sites which are not particularly high, but have plenty of thick cover. Ringing results have shown that the birds move regularly from roost to roost and that, in general, they are a mobile and 'nomadic' species. There are not many indications of movements over 200 or 300km (120-180 miles) within the British population, but many birds from the northern part of the European range travel 1000km (600 miles) or more each autumn and spring.

Cold winter weather is not a serious threat to survival – provided that the feeding grounds are clear of snow. If the weather is very cold and the day-length is very short, they may find it difficult to take in sufficient food to see them through the night. In such circumstance, and during snowy weather, many more may join the flocks feeding in gardens.

Human help Greenfinches visiting gardens take almost any sort of seed. Hemp, peanuts (loose on the ground or hanging) and particularly sunflower seeds are favourites. As with many species observed at feeding stations, the numbers seen at any instant in a garden are a tiny proportion of all the individual birds using the site through the whole winter.

As many garden bird feeders know, the number of greenfinches seen in gardens reaches a peak in March and April, and many are still present in early May. Ringing returns show that this is the period when more greenfinches die in the wild than at any other time of year. This is easily explained, for the birds have been exploiting a stock of seeds which has not been replenished naturally since the autumn. The food supply has thus

summer plumage

The song flight

The spring display of the greenfinch includes an interesting song flight. The male performs a circular flight over his territory, flapping his wings in an exaggerated and noticeable manner.

Greenfinch distribution

Greenfinch (*Carduelis chloris*). Resident in Britain and Ireland; partial migrant on the Continent. Habitats include woodland edges, gardens, shrubberies and farmland. 14.5cm (5¾in).

Left: Nesting begins in late April or early May. With six eggs, this is a good clutch for greenfinches; many have only four.

Above: A male greenfinch in flight. The two flight (and contact) calls are 'chup, chup, chup' and 'chit-chit-chit-chit-chit'. When the bird is seen in flight the yellow wing patches and tail edges are conspicuous.

Below: A greenfinch bathing in a stream. Note the stout body (even allowing for the fluffed-out feathers) and the clear pink beak.

run out, and continued feeding–by people who put out food for birds in their gardens–is particularly important.

The breeding season During the spring, the males start to give their 'dreeeez' summer call. When displaying, they precede this by a rather weak, chattering song. Displaying males may sing and call from the top of a tree or bush, or may advertise their presence in a characteristic song-flight. In most cases several pairs take up territories close together, each male defending only a small area round the chosen nest site.

The nest is built of twigs, roots and moss in late April or early May, and is lined with fine grass, roots, hair, wool or feathers. Four to six eggs are generally laid in each clutch and incubated for two weeks. The chicks are fed on insects for the first few days, but soon the diet is changed to regurgitated seeds. Two or three broods are often raised by a single pair, and young may sometimes be found in the nest as late as September.

Countless hazards In ideal conditions, the two or three broods raised by a single pair of greenfinches could be expected to produce a total of about 20 birds where there had been only two at the beginning. Nature is not in fact so profligate, for although a highly successful pair may be able to produce three large broods, the great majority of breeding attempts actually fail.

Failure arises in many ways–lack of food may cause starvation, one of the adults may die or be killed, or a predator may find the nest and eat the eggs or young. Apart from these dangers, the eggs might be infertile, the nest may be blown out of its bush or the bush may be destroyed during agricultural or gardening work.

In any case, the production of eggs and the successful fledging of young is not the end of the parents' responsibility, for they also have to look after the young birds, out of the nest, for a period of ten days or more, while they learn about the world and how to find food for themselves.

Resilient population Besides all the difficulties that they have to face at breeding time, greenfinches are affected by wide variations in winter weather conditions from year to year. Despite this, the British breeding population, as shown by the Common Birds Census index, has remained constant over the last 20 years. The two cold winters in 1961-62 and 1962-63 probably halved the population, but it had returned to an average level by 1966.

Since then it has varied by less than 10% either way, except in 1975 when it was rather higher than normal. These figures are based on observations made on farmland–probably the habitat holding the most stable populations. The figures relating to woodland are based on a smaller sample and show a rather greater fluctuation. The highest woodland population they indicated was in 1966.

The prospects for this attractive bird look excellent, with range expansions being reported during the present century. These have occurred in western areas, where the birds were formerly absent, and also in city centre areas. The most serious problem which they are likely to face arises from the increasing use of herbicides in cereal growing and other farming. If the trend continues, the range of species of weeds which are able to seed and thus produce natural winter feeding for the birds may be reduced. On current evidence, it seems likely that human bird-lovers will more than make up for the deficiency, with the plentiful supplies of seeds and peanuts that they put out for the birds in their gardens.

SIX SPECIES OF PLANTAIN

From lawns and driveways to saltmarshes and sand dunes, few groups of plants occupy such a range of habitats as the plantains. There are six species in the British Isles, of which five are native, including the great plantain (pictured below).

Of our six species of plantain, the one most familiar to people is the plant that forms flattened rosettes in our gravelled paths and drives or in the bare mud of a well-trodden lawn. This is the great plantain, also known as waybread from the Old English 'weg broade', meaning 'broad way'. It is one of the few plants that can survive in such an unpromising habitat as a gravelled path; in fact it does not grow well in more fertile habitats since it cannot compete with the luxuriant vegetation to be found there.

Rosettes of leaves Like all plantains, the great plantain produces a rosette of leaves from which several fibrous roots penetrate into the ground. The leaves are dark green

and tough, with the stalks as long as the blades, and they all grow directly from the base of the plant in the manner of a rosette.

The flower spike, which bears no leaves, arises from the centre of the rosette and usually carries a multitude of small, insignificant flowers. Each flower consists of four green sepals and four yellowish-white membranous petals. Any attractiveness that the plant may have lies not in the petals but in the prominent anthers, which project well beyond the flowers and are lilac at first, later fading to yellow. The flowers are wind-pollinated, the pollen being blown from the protruding anthers to be caught on the rough surface of another flower's stigma. The fruits of the great plantain are oval and brown, at one end being encased in the four sepals remaining from the flower.

Extensive environmental studies have been carried out on the great plantain and it has been discovered that considerable morphological differences (ie, differences in shape and size) occur between plants growing in different environments. Most plants exhibit such differences, but rarely to the degree of great plantain. Those in undisturbed, well-manured vegetable gardens, for example, may bear leaves up to 60cm (2ft) long with several large flower spikes and as many as 450 individual flowers. At the other end of the scale, plants growing in hard-packed mud on the edge of a well-trodden path may be no more than 5cm (2in) in diameter, with tiny flower spikes bearing just a few flowers.

As with other plantains, the great plantain has played a significant role in folk medicine–since it is so resistant to bruising and injury it was thought to be useful for treating wounds and sores, the leaves being used in poultices or boiled to extract the juices. Birds are very fond of the seeds of this plant and the fruiting flower spikes are still gathered near London and other cities to provide food for caged birds.

Black plantain Though perhaps the most familiar British plantain, the great plantain is not the most common. This title goes to the black plantain or ribwort, a plant found growing in short turf on non-acidic soils.

In its general shape this plant resembles the great plantain, though its leaf stalks are much shorter, being only about half the length of the blade. The name ribwort comes from the conspicuous ribs which run the entire length of the leaf, from the base of the stalk to the tip of the blade–a common children's pastime is to extract these ribs and use them as strings. The flower stalks on the black plantain are furrowed, a feature that distinguishes it from other British plantains which have rounded stalks. The flowers of black plantain are also distinctive for being black with white anthers–hence the plant's common name. Studies on this species have revealed the same type of morphological variation as that seen in the great plantain.

Many farmers regard ribwort as a weed and eradicate it, yet it could be a valuable supplementary source of food for livestock. The leaves remain on the plant throughout the winter, when greenstuff for grazing often becomes scarce; sheep are fond of the leaves and horses and cattle will also eat small

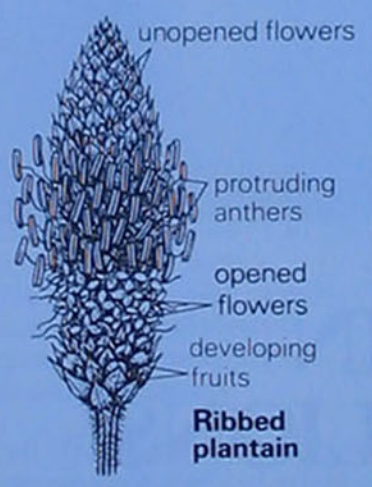
Above: The lance-shaped leaves of ribwort account for its Latin name, *Plantago lanceolata*, while the narrow leaves of sea plantain (*P. maritima*), shown below, are an adaptation to its coastal environment.

Above: The hoary plantain (*P. media*) gets its common name from the numerous pale hairs that cover the surface of its short-stalked leaves, giving them a greyish colour in contrast to the greenish leaves of other plantains.

Left: In flower the hoary plantain becomes the most attractive member of this group, with its lilac anthers set against the silvery-grey background of the flower spike.

Plantain flower structure

The flowers of a plantain are extremely small—just a few millimetres across—and borne in great numbers on a spike, which may be long and thin or short and rounded, depending on the species. The flowers themselves have a complicated structure in which four petals and four sepals sit at either ends of the ovary. Projecting from the centre of the petals are a stigma and four long styles; also present are several prominent and often highly coloured anthers. The flowers open sequentially up the spike, those at the bottom nearest the stalk opening first and those at the top opening last.



Ribbed plantain

amounts. Furthermore, the leaves of ribwort are high in vitamins and minerals, while grasses are often deficient in these substances. This plantain could, therefore, be extremely useful to the farmer. The problem is that it is not easy to control weeds selectively, killing the harmful ones while leaving the beneficial ones such as ribwort alone, the reason being that modern weedkillers are designed to kill all broad-leaved weeds regardless of whether or not they are useful.

Hoary plantain On chalky soil the black plantain is often joined by the less common hoary plantain, so-called because its leaves and flower stalks are covered in silvery hairs. This is the only plantain with scented flowers, despite the fact that they are wind-pollinated. However, it seems that the flowers can also be pollinated by insects, since both flies and others are attracted by the scent.

Coastal plantains Britain's two remaining species of plantain are both coastal. The buck's-horn plantain differs from the three species so far mentioned in not being a perennial. It is sometimes an annual but more commonly a biennial, forming a rosette the first year and flowering, setting seed and dying the second year.

The buck's-horn plantain is most often seen on dry open ground—such as paths, dunes and cliffs—in sandy soils near the sea. It has narrow, deeply lobed leaves, with long flower stalks and green flowers. This species can tolerate a high concentration of salt in the environment (as its presence in sand dunes testifies), but another species, the sea plantain, is even more salt-tolerant. This biennial plant grows in saltmarshes and, like many of our maritime species, is also found on mountain screes, often beside streams.

The sea plantain has narrow fleshy leaves and the flowers are brownish with yellow anthers.

Britain's solitary introduced species of plantain found growing in the wild is *Plantago indica* (it has no common name). It is a small insignificant plant with narrow leaves and brownish flowers. An annual, it grows on disturbed ground and sometimes on dunes.

Shoreweed

One other species in the plantain family is native to Britain. This is shoreweed. It grows on the margins of ponds and lakes and looks very different from plantains such as the buck's-horn plantain shown here. Instead of a spike of minute flowers, it has separate male flowers borne on the tips of a branched stalk, with the females lower down.

Buck's-horn plantain *(Plantago coronopus)*

Shoreweed *(Littorella uniflora)*

MITES IN THEIR MILLIONS

Mites, like insects, have succeeded in colonizing almost every habitat in the world. Although approximately twenty thousand species have now been discovered, this is probably only a fraction of the numbers that actually exist.

Mites belong to the class Arachnida, which includes spiders, harvestmen and ticks; they differ, however, from all other arachnids in their small size and the absence of any clear body sub-divisions.

Mite features The bodies of most mites range in length from 0.1mm-16mm, and are usually oval in shape. There is an outer skeleton or cuticle which varies in thickness according to the order to which the mite belongs, and is often intricately patterned. The hair-like projections (setae) on the cuticle are sensitive to touch or chemicals and provide the mite with information about its environment. Their shape, number and arrangement are all important for identification.

The basic mite life-cycle begins with the egg hatching into a larva-like creature–a stage easily identifiable since the 'larva' has only three pairs of legs, instead of the four pairs found on nymphs and adults. Following the 'larval' stage there are three nymphal phases before the adult emerges–a moult occurs between each phase.

Four orders British mites represent four orders. The Astigmata are soft-bodied mites comprising both free-living species and parasites. The Cryptostigmata, heavily armoured mites with thick, dark cuticles, are roughly globular, and feed on dead and decaying organic matter, fungi and algae.

The Mesostigmata are robust mites with brown shields–thickened areas of cuticle–covering the body. Most species prey on nematodes, small insects and other mites, or parasitise vertebrates. Lastly there are the Prostigmata, an order of soft-bodied and often brightly coloured mites that feed on fungi and parasitise plants, vertebrates and invertebrates.

Ubiquitous mites Free-living terrestrial mites are found from the lowest tidal zones to mountain tops, in dung and tree-holes, and on all kinds of fungi, lichens, mosses and higher plants. The highest numbers occur where decaying organic matter is abundant, usually in meadow and forest soils. In such habitats mites are invariably the most numer-

Above: If you come across a mass of silk on some gorse, look carefully inside the silken structure and you may see the spinners –tiny red spider mites.

Right: *Parasitellus fucorum* parasitising a bumble bee.

ous animals.

These free-living species, which feed on decaying plants, play a vital part in the composition and chemical recycling processes which return nutrients to the soil.

House-mites The species which infest stored foods (flour, cheese, jam etc) mostly belong to the order Astigmata. Some of these mites feed on the moulds growing on food products and may increase to vast numbers. Although they are not harmful, they can be a nuisance. The house-mite *Glycyphagus domesticus*, a well-known species, thrives on furniture upholstered with vegetable fibres and on rush matting in damp, musty houses.

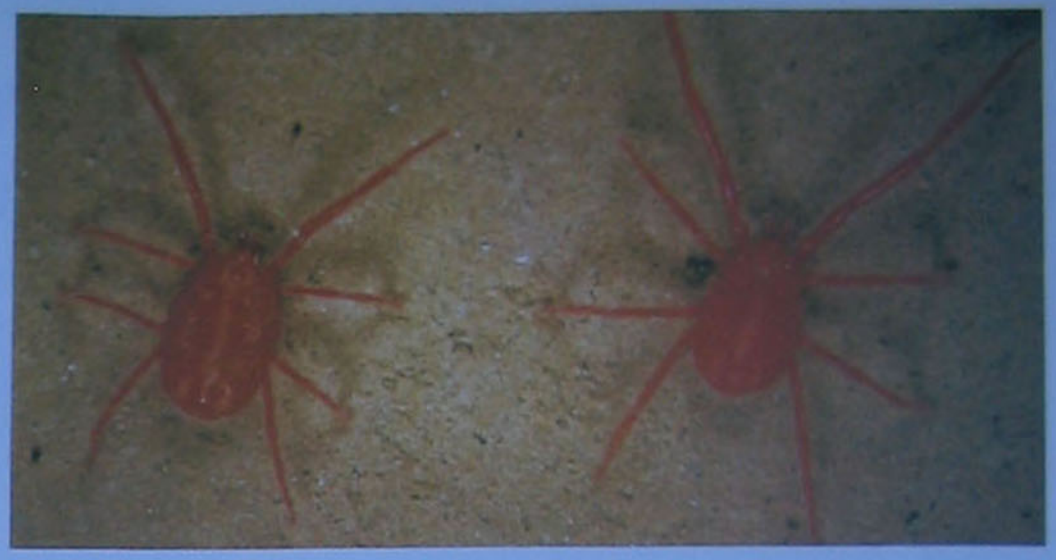
Most houses harbour mites, collectively known as house-dust mites, which feed on the sloughed human skin cells and hair fragments found in dust.

Living plant feeders The majority of mites that feed on the tissues of living plants belong to the order Prostigmata. One of the families in this group, the Tetranychidae or spider mites, includes many pests. The glass-house red spider mite (*Tetranychus urticae*), for example, causes damage to cucumbers and tomatoes.

All the Tetranychidae have mouthparts modified to form a needle-shaped projection for piercing the plant epidermis, and a tubular part for sucking up the sap.

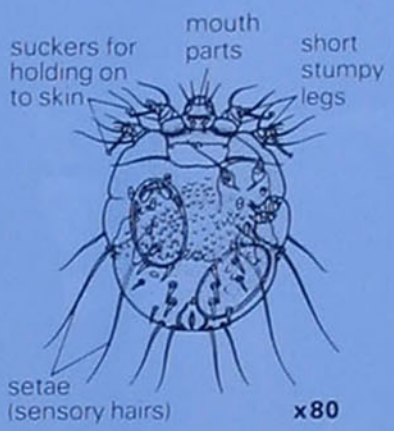
Although better known as soil and litter inhabitants, several cryptostigmatid species are associated with living plants. *Humerobates rostrolamellatus*, for instance, often occurs in large numbers on fruit trees where it feeds on algae growing on the bark.

Parasitic mites Reptiles, birds, mammals, insects and other arachnids are all potential hosts for certain species of parasitic mites, although the relationships range from true parasitism to commensalism.



Above: Mites belonging to the order Prostigmata are soft-bodied and usually highly coloured.

Right: The Cryptostigmata mites are sometimes nicknamed 'beetle-mites' because of their appearance.



Above: The upperside of the itch or scabies mite (*Sarcoptes scabiei*), a skin parasite which infests dogs, horses, cattle and rabbits, as well as humans.

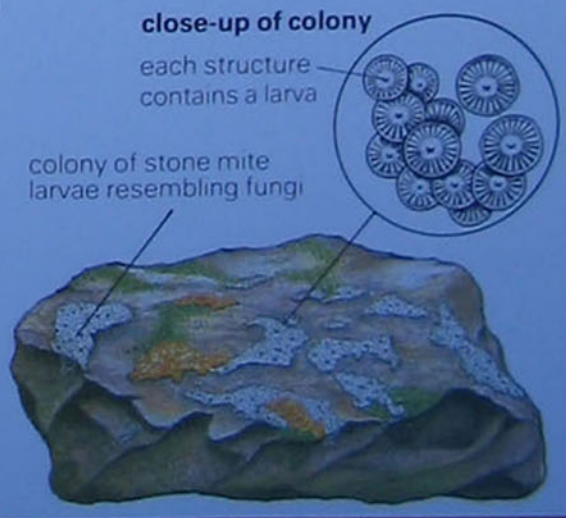
Left: *Trombidium* mite larvae feeding on a marbled white butterfly.

Most parasitic mites attack the external parts of their hosts but, unlike many parasites, they do not stay on their hosts all the time. The red-mite of poultry, *Dermanyssus gallina*, for instance, only feeds at night.

Other mites are only parasitic at certain stages of their life-cycle. The harvest mite (*Neotrombicula autumnalis*) infests nearly all warm-blooded animals. In late summer the larvae congregate on the ground and then swarm on to any suitable host which passes by, to feed on the blood. Having fed, the larvae drop to the ground and bury themselves in the soil, where they develop into adults that prey on small insects and are never parasitic.

Blood from a stone

Clusters of small white sombrero-like objects, which could easily be mistaken for fungi, are often seen on stones. Each structure contains the larva of a stone mite; if you press a finger-nail on to the colony a blood-like fluid oozes out, giving the impression of blood issuing from the stone. This is, in fact, the body fluids of the larvae.



HORSE-POWER: HEAVY HORSES

Heavy horses are making a come-back as working animals to an extent that would have been unthinkable only 15 years ago. The spiralling cost of oil has led to their re-introduction on farms, in forestry and in towns for pulling brewery drays.

Right: The Clydesdale is often confused with the Shire, but can be distinguished by its straight profile.

Opposite page: A team of three heavy horses harrowing a ploughed field. Horses are cheaper than tractors and they can breed their own replacements. A mare needs only a week or so off for the birth and early rearing of her foal, which will itself be ready for work at three years old and may have a working life of ten or more years.

Below: Shire horses hay-making. They are often known as 'gentle giants' because of their placid temperament.

Britain is fortunate in having three 'home-bred' breeds of heavy horse – the Suffolk Punch (usually known as the Suffolk), the Shire and the Clydesdale, and one naturalised breed, the Percheron. There are some farmers for whom they have always been an integral part of the 'machinery' of the farm, but an increasing number of farmers are finding horses more economical than a tractor for carting, ploughing and drilling. Similarly in forestry it is well known that horses do less damage than mechanised transport and that they can reach areas where tractors cannot go; this, plus overall lower running costs, has ensured that more horses are being used. They are also well known in such towns as Aberdeen, where Clydesdales are used in the parks department, and in many cities where they deliver beer.

The Suffolk Punch The Suffolk is the oldest established British heavy horse (being mentioned as early as the 16th century) and the most easily recognised. Suffolks are always chesnut (the unusual spelling is traditional) and one of the following seven shades: dark brown, mahogany or liver, dull-dark, mealy, red, golden, lemon and bright chesnut, with the latter being most popular and numerous.

The Suffolk, together with the Percheron, and in contrast to the Shire and the Clydesdale, does not have any feathers (long silky hair below the knees); of the four breeds it is the most solid and chunky in appearance, with a wide chest and strong legs.

As the name suggests, the Suffolk's home is East Anglia. The breed is unique in two respects. It is the only British heavy horse that has been bred entirely as an agricultural animal; consequently over the years breeders have produced an animal with a low-set shoulder that is ideal for pulling implements through heavy soils. Secondly, every Suffolk can trace its ancestry to a stallion foaled in 1768, known as 'Crisp's Horse of Ufford'.

The Clydesdale Today's Clydesdale is not very different from a Shire in appearance. It tends to be a little lighter in build and longer of leg. One of its distinguishing features is its trot, which is described by the breed society as a 'high stepping action that makes him a singularly elegant animal among draught horses', and is noticeably more flamboyant and jaunty than the measured dignity of the heavier Shire.

The history of the Clydesdale as a breed stretches back little more than 150 years to the Clydesdale area of Lanarkshire, although as early as the 15th century attempts were made to breed a draught horse by crossing the larger English ponies with smaller native ponies. The modern Clydesdale is predominantly bay or brown, with some greys, blacks and roans.

The Shire and the Percheron Although the Shire is descended indirectly from the heavy

Above: An old saying goes: 'With a real Suffolk you should be able to stand a walking stick under his belly and drive a wheelbarrow through his front legs'.

Below: Shire horses resting from their efforts towards making a haystack.

horses brought from Europe after the Norman Conquest, the breed we now know did not actually take its name until the end of the last century. The Shire is a majestic animal, epitomising the strength and power allied with a placid temperament that has given rise to the affectionate title of 'gentle giant'.

The Percheron has a long and honourable history in France dating from the 8th century, but it first became known to the British during the First World War. A crash breeding programme was introduced to provide more horses for the army, and since then the Percheron has been part of the British horse scene, initially in horse buses and then in agriculture and commerce. It is a well established breed in East Anglia. Most Percherons are a beautiful dappled grey (it is said that the original rocking horse was based on this breed), or black, with 'clean' (without feathering) legs. In this country it is a most elegant breed of draught horse, but in France it is bred almost entirely for meat and is rather coarse.

Why horse-power? Heavy horses are still cheaper to buy than even small tractors, and they breed their own replacements. In addition, when the quota of horses on a farm is sufficient for the work required, any surplus foals can be sold at a reasonable profit. Tractors decrease in value from the time they are bought, whereas horses increase in value until they are seven or eight and have a working life of ten or more years.

Horses are expensive to feed with food from retailers, but most horse-powered farms grow their own feed, using 'break' crops of oats, grass or roots. The horses in turn provide excellent organic fertiliser which enriches the soil and helps to keep it friable.

Perhaps one of the most persuasive arguments in favour of horses over machinery is that they are intelligent animals which can be schooled to respond to the voice. When carting food to stock, for example, some trained horses obey commands to stop and start, leaving the farmer free to attend to the feeding. Similarly with operations such as drilling trained horses plod steadily up and down the field, leaving the farmer to attend to fences or ditches. When the drill needs to be re-filled, all that is needed is another word of command and the horse comes to the seedbags, stops, turns, backs-up, waits and then moves off again. Horses are particularly suited to tackling jobs on land unsuitable for tractors because of excessive gradients or the wetness of the soil.

There are ecological advantages as well. Constant use of tractors causes soil compaction. The huge tyres going backwards and forwards pack the soil solidly, preventing the free passage of air and water and making it harder for crop roots to penetrate. This eventually leads to poor drainage. With horses, compaction only occurs where each foot is placed.

The problems Horses are slow compared with tractors. A single horse ploughs, on average, about an acre a day, compared with five or more by a tractor. However there is a move afoot among some horse farmers to introduce implements that were a feature of the great wheat belts of North America before mechanisation. By using five or six horses the same amount of work could be done as with a tractor, and for less cost.

There is a general lack of implements for horses. When mechanisation arrived horse-drawn implements were mostly scrapped and there are now no manufacturers. But as the return to horse-power gains some momentum, means are being found to adapt modern implements to horse-power.

Another problem is the shortage of men with the knowledge and experience of horse management and farming, although there are many who are keen to learn. Farmers who use horses are inundated with requests from people keen to be taken on to gain the necessary skills. Many farmers wonder whether sufficient young men would be prepared to work the long hours and accept the long-term responsibility of looking after the animals; but even today there are still those who are willing to care for other animals, such as cattle, sheep and pigs, so perhaps it is just a question of re-learning the old skills of horse care.

People are worried that the heavy horses now being bred are not ideal for the work they may have to do. Since the 'heavies' were replaced by tractors, they have largely been bred for hobby and show-ring purposes, resulting in taller, perhaps more elegant, animals. A horse can be too tall to pull an agricultural implement efficiently because the angle of draught (the angle between the ground, the point of attachment of the chains to the collar, and the implement) becomes too great and the horse may pull the implement out of the ground, rather than over it. Another difficulty is that the essential solid, gentle temperament is being lost as the horses are bred for fire and dash to be eyecatching in the show-ring. This is hard to eradicate, and can re-appear unexpectedly after many generations. If the time comes when larger numbers of horses are needed for working, this may have to be considered carefully.

Above: Clydesdales being stood out at a ploughing match. Ploughing matches are entertaining and they maintain high standards. A team walks about 11 miles in ploughing one acre of land.

Below: A Shire horse helps to cart mangel-wurzels (a root-crop).

THE OVER-FISHED HERRING

Herrings were once called 'silver darlings' by fishermen, and whole communities depended for their livelihood on catching and processing them. Today, however, mainly as a result of over-fishing, the economic importance of the herring is much reduced.

The herring belongs to a large family of fishes which includes sprats, pilchards, sardines and other less well known species found in many parts of the world. All of them are important as food for man and his domestic animals, or as part of the food chain of economically valuable fishes. Herrings are larger than sprats, pilchards and sardines, and when fully grown can attain a length of 43cm (17in) and a weight of 680g (1½lb), though they are often caught by fishing boats before reaching this size. The fishes are flat-sided, with a silvery colour on the belly and sides, darkening to a deep blue-green on the back.

Herrings are widely distributed in northern seas, and there are two important species. *Clupea harengus* is found in the North Atlantic from Newfoundland to Scandinavia and Northern European coasts, while a closely related species, *Clupea pallasii*, extends from Japan to Canada in the North Pacific, and also occurs in the western North Atlantic. There are two main populations of *Clupea harengus*: oceanic herrings, which are found around Iceland, the Faeroes and Norway, and shelf herrings (or European herrings) which live in the shallower European waters.

Above: These trawlers at Ballycotton in County Cork, Ireland are multi-purpose vessels: they fish for herrings when in season, and are refitted at other times to catch different fish species, such as mackerel or plaice.

Life history The shelf herrings are divided into distinct stocks, some of which spawn close inshore in spring, and some in deeper waters in summer and autumn. Sticky eggs form a mat over gravel and stones on the sea-bed or are attached in clumps to seaweed. The eggs hatch in about 10 days at a water temperature of 10°C (50°F), or longer in colder water. The larvae that emerge are about 7mm (just over ¼in) long; these are thin, scaleless, transparent creatures, furnished with a prominent yolk-sac which forms a food reserve until they start to feed actively.

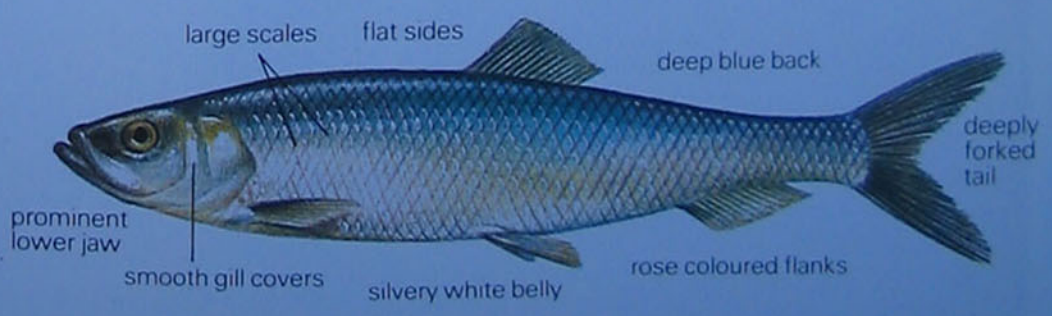
At this stage of their life, the larvae are planktonic – they float rather than swim, but can make short, darting movements to catch smaller planktonic organisms for food. Many larvae are themselves eaten by arrow-worms, sea gooseberries, young fishes and other sea creatures.

As the survivors grow, they are carried by currents into sheltered bays and inlets where, by early summer, they develop scales and true fins so that they look like small versions of their parents. They shoal in large numbers, sometimes in company with young sprats. Such mixed shoals may be caught and sold. These small fishes, some 4-6cm (1½-2in) long, are known as whitebait.

In the next 18 months they usually undertake complex feeding migrations before joining the adult shoals as 'recruits'. Young herrings spawned from different stocks may be mixed together on the feeding grounds, but it is believed that they separate as they mature and go back to their own spawning areas at an age of two or three years or more, when they attain a length of at least 20cm (8in).

Eat and be eaten Herrings eat plankton, particularly copepods, all their lives; as they grow older they are able to select and catch individual larger planktonic organisms. Adult herrings have a varied diet which includes copepods, other small crustaceans and young fishes such as sand eels. They feed in mid-

Features of a herring



Herring *(Clupea harengus)*

water and are therefore called pelagic fishes (as opposed to demersal fishes which feed mainly at or near the sea-bed). Herrings move upwards towards the surface at night, and down towards the sea-bed during the day. They are preyed upon by many carnivorous fishes, by whales and also by seabirds; but by far the most serious predator is the fisherman.

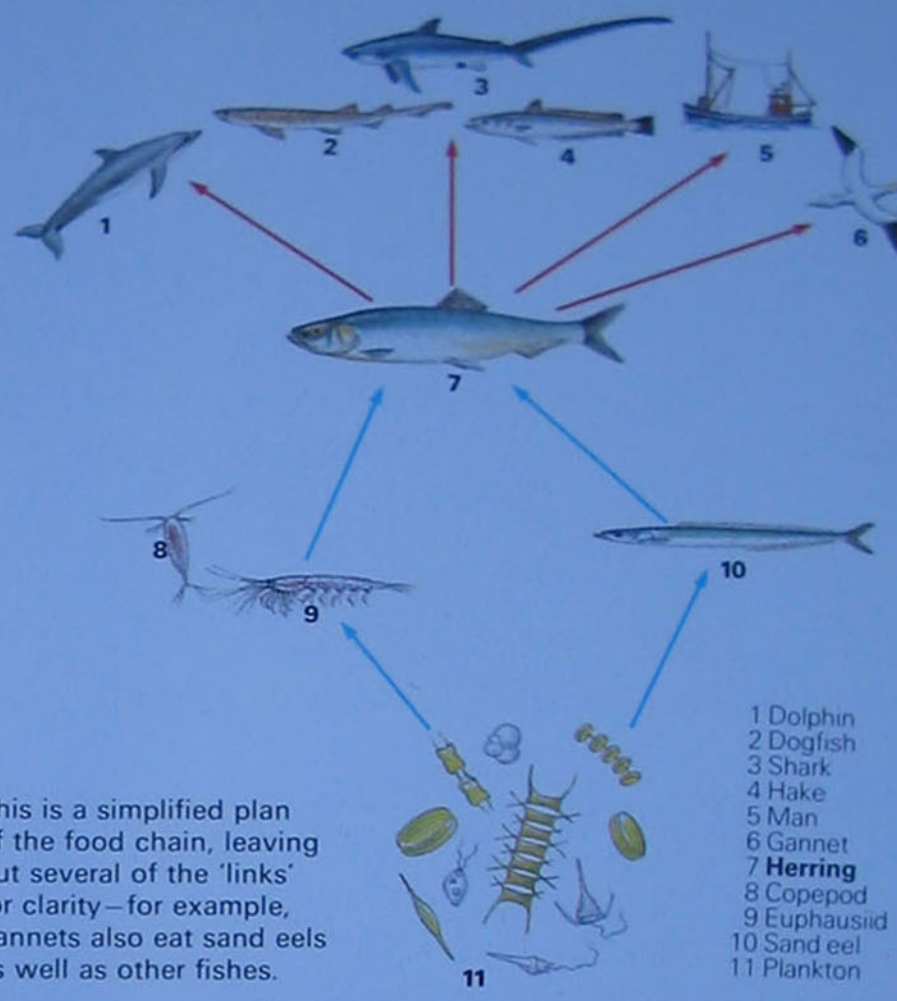
Fishing methods For centuries, the traditional method of catching herrings was by drift net. In this method, flat sheets of netting, weighted at the bottom and buoyed at the top, are linked together in 'trains' which may be several kilometres long. The nets are shot (lowered into the sea) at dusk and the ship then drifts with the nets to await the 'swim', when the herrings move up towards the surface water and are caught as they try to swim through the net. The advantage of this method is that the mesh size can be chosen to take only the larger herrings, leaving the younger fishes to grow heavier and more valuable, as well as breed new recruits to the shoals.

After 1945, with the advent of sophisticated instruments for fish detection, drifting gradually gave way to more active pursuit of the herring. Shoals located by echo sounders and sonar equipment can be swept into large trawls operated by one boat or a pair, with the gear adjusted to catch the fishes near the bottom or in mid-water. Purse seine nets, large enough and deep enough to enclose a cathedral, can be laid around a shoal and closed by tightening lines at the lower end to form a 'purse' completely surrounding many tons of fishes, which are then transferred to fishholds or refrigerated seawater tanks.

Processing the catch Relatively few herrings are retailed fresh. They may simply be salted whole, or they may be salted and smoked (kippered) or marinated with spices. Young herrings of about 10cm (4in) in length are canned in oil or sauce. Frozen fillets prepared from fresh or kippered herrings are packaged for quick and easy cooking. Herring roes, too, are considered to be a delicacy.

Management of herring fisheries Herring stocks have always fluctuated in size. Changes in natural conditions affect spawning success and viability of larvae and young fishes, so that recruitment to the adult shoals can vary dramatically from year to year. It was believed for a long time that the influence of fishing was small in relation to environmental effects, but recent events have shown this to be wrong. More fishes were caught than could be replaced by recruitment, and stocks began to dwindle. The need for management was recognised and conservation measures were applied – too little and too late in many cases. The herring catch in the North Sea and in the Skagerrak declined from around one million tons in the late 1960s to less than 50,000 tons in 1977.

The herring in the marine food chain



This is a simplified plan of the food chain, leaving out several of the 'links' for clarity – for example, gannets also eat sand eels as well as other fishes.

1 Dolphin
2 Dogfish
3 Shark
4 Hake
5 Man
6 Gannet
7 **Herring**
8 Copepod
9 Euphausiid
10 Sand eel
11 Plankton

The main methods of fishery management are scientific assessment of the size of present stocks, projections of the effect of various levels of fishing, and regulations designed to ensure an appropriate fishing level. Various regulations have been made to control the number of ships fishing, and to set limits on the quantity and minimum size of herring that may be caught. There has been a reduction in catches allowed for 'industrial' use (the manufacture of meal and oil to make animal feeds and fertiliser) and, as a last resort, direct herring fishing has been prohibited in certain areas of the sea. In those areas which have been closed for a period of three years, the herring stocks are recovering.

Below: Herrings fresh from the sea, in a tub aboard the research ship that landed them on a voyage on the Irish Sea. Herring scales are very loosely attached, and rub off easily: here some scales can be seen on the wooden boards beside the fish. When they are caught in trawls or seine nets, herrings rub against one another a great deal and lose virtually all their scales. This is why, when bought in shops, they often appear to be completely scaleless.

Above: The purple autumn leaves of a purging buckthorn contrast with the still-green foliage of a neighbouring hazel bush.

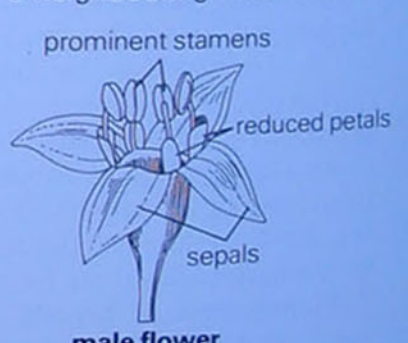
THE POISONOUS PURGING BUCKTHORN

Long used in medicine for the purgative properties of its bitter, poisonous berries, the purging buckthorn is our only true buckthorn to bear thorns. Though not a familiar plant to many country ramblers, it is surprisingly common in the hedgerows and thickets of Britain's chalk downs.

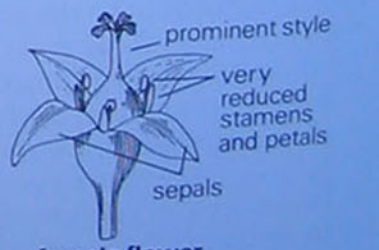
In the British Isles there are only two native species of buckthorn that belong to the buckthorn family, Rhamnaceae. These are the alder buckthorn and the purging buckthorn. (A third native species, the sea buckthorn, belongs to a quite different family, the oleaster family, Elaeagnaceae.) Of our two true buckthorns, only the purging buckthorn is strictly entitled to its name, for the alder buckthorn is thornless. The two species are placed in different genera, the purging buckthorn in *Rhamnus* and the alder buckthorn in *Frangula*, primarily because of differences in their winter buds: the winter buds of the former are covered in scales whereas those of the latter lack these scales.

Orange bark The purging buckthorn is a deciduous shrub, though it may form a small, well-branched tree attaining a height of 5m (16ft). The bark on the branches of older trees is fissured and a blazing orange in colour but on younger trees it is much smoother and paler. The most obvious characteristic of this plant is its stiff thorns, which occur at the tips of small branches. These thorns are said to resemble a roebuck's antler – hence the name buckthorn.

In April the leaves appear. These are yellowish-green and broadly oval with finely toothed margins, a feature lacking on the alder buckthorn. Most of the leaves are clustered towards the ends of the shoots but



male flower



female flower

Above: Male and female flowers are borne on separate plants, each having fertile floral parts of its own sex and sterile parts of the opposite sex.

lower down on the plant they are more scattered and many are borne more or less in pairs. The leaves of the purging buckthorn are marked with up to four prominent pairs of veins that converge towards the leaf tip, a feature also found in the leaves of the unrelated shrub, dogwood.

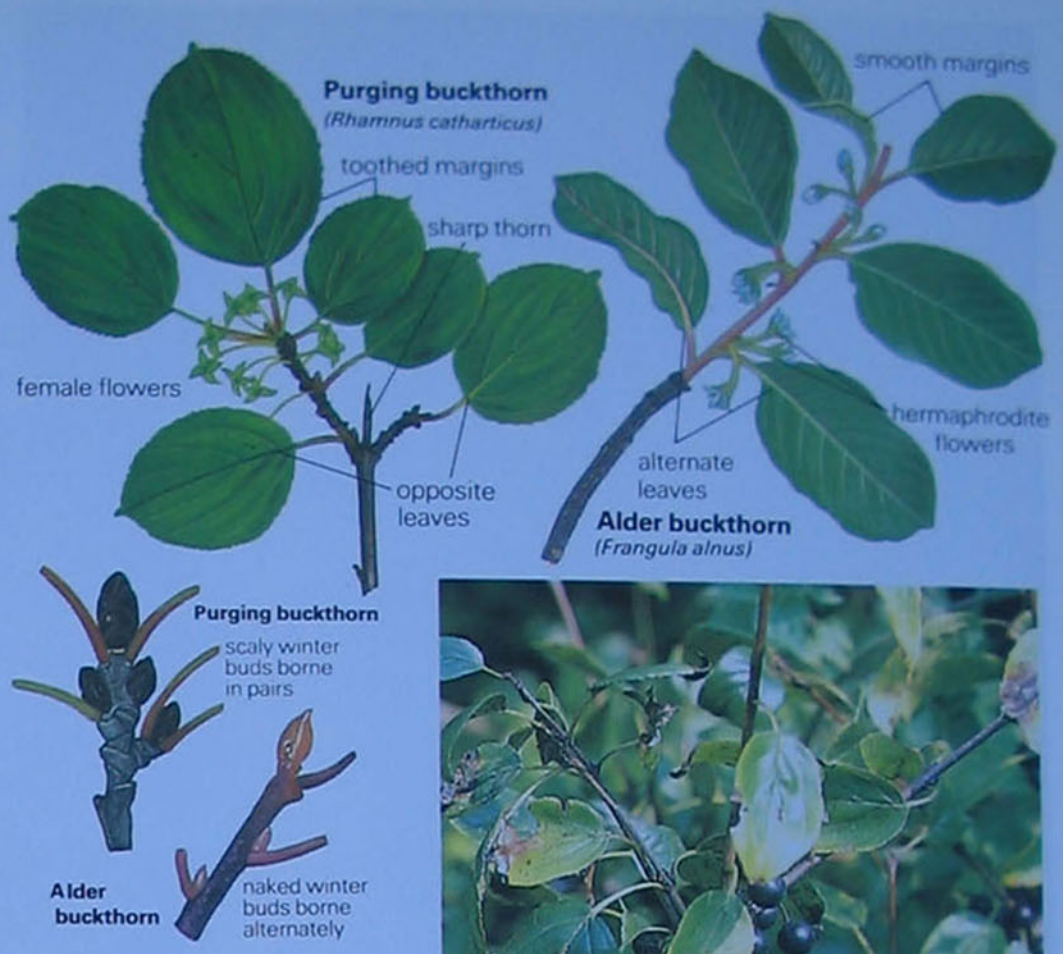
Scented flowers From May to July the purging buckthorn produces tiny yellow-green flowers only 5mm in diameter. Being so inconspicuous these flowers do not attract pollinators such as bees and wasps by their size or colour. Instead, they emit a strong scent, tempting these insects to feed on the copious amounts of nectar found at the base of the petals.

The flowers occur singly or in small groups in the axils of the leaves. Each has four petals and is either male or female–flowers of different sexes being borne on separate plants. In the centre of the male flower, surrounded by the pollen-bearing stamens, is a very small, sterile style, which is not visible externally. This situation is reversed in the female flower, for the style is fertile and prominent, bearing a four-branched stigma, while surrounding it are four very small and ineffective stamens.

Purging berries Towards the end of the summer the female flowers develop into fleshy green berries, inside which can be found four stones, each encasing a seed. The berries ripen to become black and between September and November, depending on when the flowers were formed, either fall to the ground are carried away by birds.

Many parts of the purging buckthorn are poisonous to humans–even the bark and twigs–but the berries are the most dangerous. Soon after they enter the stomach the berries cause an intense gripping pain, followed by diarrhoea, sickness and a severe thirst. Yet the berries have long been used as a laxative; the purging buckthorn is mentioned in medieval writings, when it was known as hartshorn or waythorn, and during the 19th century syrups prepared from buckthorn berries were a popular laxative for children. Today, however, only animals are prescribed buckthorn juices.

Buckthorn wildlife Like so many of our native plants, the purging buckthorn plays an important role in the food chain of insects, birds and animals. The brimstone butterfly, for example, feeds on only two species of plant, of which purging buckthorn is one and alder buckthorn the other. The red-backed shrike uses the thorns on which to impale its prey, and ground-feeding birds such as the song thrush and the blackbird take full advantage of buckthorn berries that have fallen to the floor–despite the purging effects of the berries there is often not much else for such birds to eat at that time of year. The bodies of these birds retain the purgative properties of their meal, as predators on them find out to their cost.

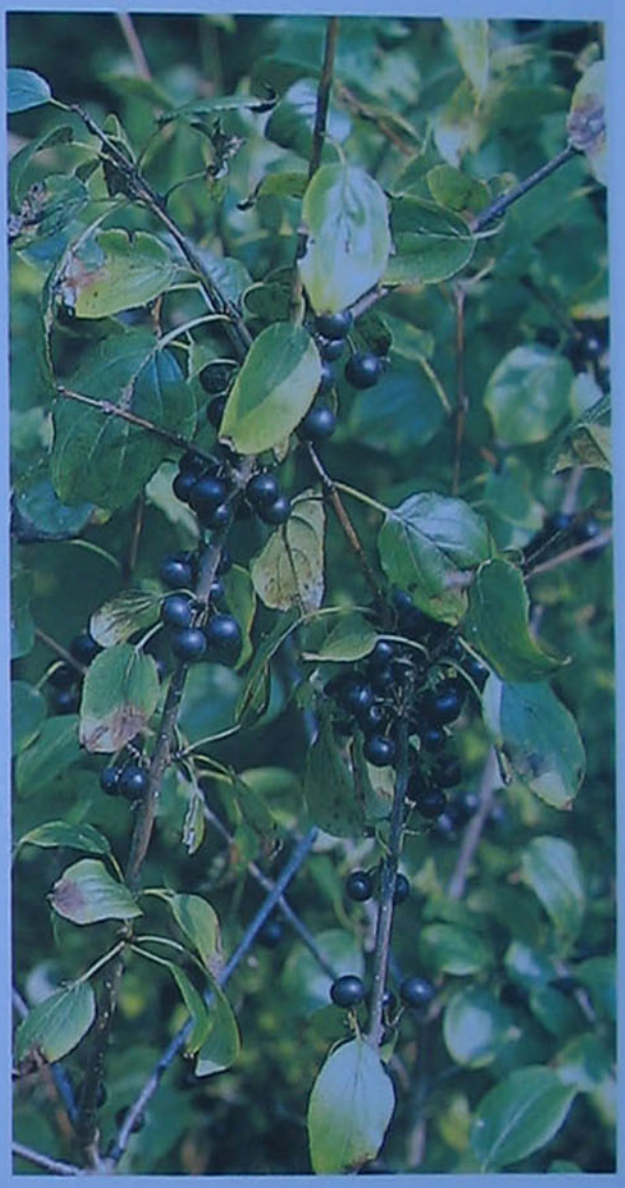


Above: Purging buckthorn is best distinguished from alder buckthorn by the shape and arrangement of its leaves. In winter, look to see whether the buds are covered in scales or whether they are naked.

Purging buckthorn (*Rhamnus catharticus*). Native deciduous shrub of thickets and hedgerows on chalky soils. Height to 5m (16ft).

Right: The ripe berries were once an important ingredient in the pigment variously known as bladder green or sap green.

Below: These male flowers are small and inconspicuous, as are the female flowers.



NATURE'S HIGHWAYS

As they travel in search of food, mates and shelter, animals follow their own 'highways' – the hedgerows, walls, fences and rivers that thread the countryside of Britain.

Much of the British landscape is made up of a patchwork of fields and field boundaries, occasionally interspersed with natural features such as woods, rivers and lakes. Wherever necessary the countryside has been partitioned in order to manage and farm it effectively. A close look reveals that it is also dissected by a wide variety of animal paths, ranging from a few inches wide (those made by small rodents such as mice, voles and shrews) to several feet in width (made by larger mammals such as badgers, deer and foxes).

These animal highways serve the same function as our roads and tracks in allowing animals to move easily from place to place. However, animals have to choose their highways with some care since, unlike man, they are susceptible to predation. They must travel by the most sheltered routes available, although this may necessitate going further – around the edge of a field, for instance, rather than straight across it. Field boundaries offer some shelter and they are exploited as relatively safe highways by an abundance of wildlife. If you look carefully beside a hedge or wall, fence or river, you may see a small but well-trodden path running alongside it; furthermore, in a hedgerow you may see well-worn runs through the hedge where animals have crossed from one side to another.

Animal travel routes Natural highways are

Above: An English patchwork of fields, woods and hedges. Where the hedges, walls and fences form a continuous, countrywide network, animals are fairly safe in their travels. In places, however, they may have to venture across open land (fields or heathland), taking refuge and finding food in copses and woods where available.

Below: A radio-collared farm cat perched on a fence. Its movements are monitored as it patrols the boundaries of its territory.

exploited by animals for a variety of reasons. First and foremost, they offer a sheltered route for animals to travel from one point to another. Animals need to move about the countryside in search of the resources necessary for survival. They cannot stay in one spot and expect food, for example, to come to them.

Movement in search of a new home is called dispersal and typically involves juvenile animals (young foxes and weasels, for instance) which have been expelled from their natal range at the end of summer, and are forced to travel until they find a vacant area in which to settle. Solitary species, such as hedgehogs and squirrels, will also travel long distances in search of a breeding partner.

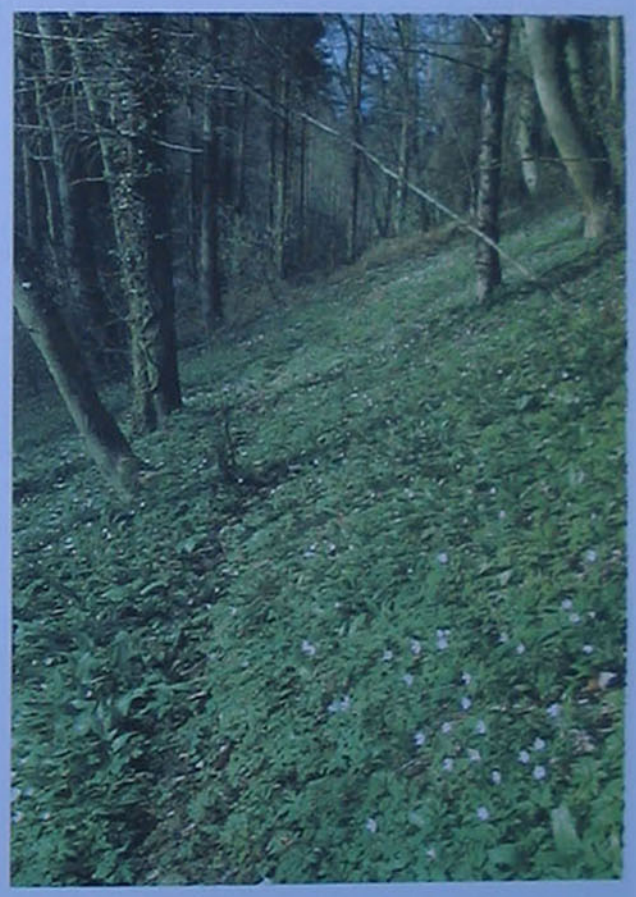
An obviously important resource is food; animals move along their highways in search of food, either within the highways or in adjacent land. Furthermore, nature's highways frequently form territorial boundaries and animals travel along them in order to define and defend them. Scent marks (those of foxes and badgers, for example) are commonly used to delimit a territory and these have to be replenished at frequent intervals.

In addition to the uses described above, highways are exploited for shelter, nest sites and resting places.

Nest sites Field boundaries provide sheltered locations for nests. Numerous birds and small and large mammals build their nests in hedgerows, walls or banks for the food, shelter and easy access to other areas that they provide. Regular hedgerow-nesting birds include the robin, blackbird, chaffinch, dunnock, yellowhammer and whitethroat, but the birds most dependent on field boundaries for nesting are both our native species of partridge, the grey partridge and the imported red-legged partridge. They prefer hedgerows adjacent to woodland or farmland and so the number of partridges that breed successfully each year depends on the amount and type of field boundary available. These ground-nesting birds are highly susceptible to nest predation and choose a nest site in a well-protected spot with thick ground cover wherever possible. They also use the boundaries, together with adjacent farmland, as a food source, taking green leaves of grasses and cereals in addition to weed seeds and insects.

Small mammals, such as bank voles and field mice, build their nests in hedgebanks, within hedges or in wall crevices, while larger mammals, such as feral cats and foxes, have resting sites and permanent dens in hedgerows or walls along their regular patrols. The resting sites are used as temporary refuges for part of the night or during daylight hours. Such insects as bumble bees and wasps build their nests in hedgebanks, and numerous other insects lay their eggs on hedgerow plants, upon which the larvae subsequently feed. In all these cases the nests are positioned

Above: A family of hedgehogs on the move along a narrow, worn track. Hedgehogs are nocturnal, travelling by night along sheltered paths in search of insect and other invertebrate prey.



Right: A regularly used deer track winding through woodland. Such tracks, again, are made where there is shelter to be had.

Below: The dunnock is a typical hedgerow dweller, depending on the habitat both for shelter and food. It feeds on grass seeds, chickweed and plantain seeds which fall to the ground and are easily picked up from the bare earth at the hedge bottom. One pair will defend about 100m (330ft) of hedge.

Above: A common frog on its springtime travels. Frogs and toads hibernate in ditches and hedgebanks and may migrate several miles across country via ditches, streams and damp hedgerows in search of breeding ponds and mates. Newts also exploit damp hedgerows when they disperse across country, foraging among the leaf litter. The present wholesale drainage of ditches has the effect of isolating these animals from breeding ponds.

in sheltered places with easy access to food either within the boundary itself or in adjacent land.

Dispersal routes Nature's highways are used as dispersal routes by a whole host of animals, but the overall distance travelled varies with the species. A dispersing juvenile fox travels up to 17km (10 miles) per night along field boundaries or paths in search of a vacant area in which to settle. By contrast, a young water vole dispersing along a river or stream only swims a few hundred metres each night in search of an uninhabited stretch of water. A young grey squirrel, on the other hand, may move anything between 300m (1000ft) and 8km (5 miles) along highways to nearby copses or woods, but a blowfly or greenbottle will only disperse up to 500m (1600ft or so) in search of a corpse on which to lay its eggs.

Amphibians and reptiles make great use of nature's highways. Reptiles, for instance, frequently hibernate in hedges, walls or banks and can often be seen sunning themselves on a south-facing bank soon after emerging in the spring and prior to dispersal. All three species of lizard found in this country eat the insects and spiders readily available in field boundaries. The slow worm is particularly abundant in limestone country, living in dry-stone walls or stony hedge bottoms; the sand lizard prefers sandy banks; and the common lizard can be found on woodland edges and in hedgebanks. Grass snakes and vipers also use nature's highways and hibernate in small mammal burrows in field boundaries.

Territorial boundaries Once an animal has established itself in a territory in a previously uninhabited area, or after dispossessing a previous owner, it must defend the territorial boundaries against other intruders.

These boundaries frequently follow natural or man-made land features because they are more obvious and easier to define than an arbitrary area of open land. Birds, for instance, advertise their territories by singing from fence posts or hedgerow trees along the boundary. Badgers use field boundaries to

Mammal movements

Observation of brown rat (male) and juvenile tom-cat movements reveal how they utilise highways on a farm.
Brown rat: **A** home burrow; **B** movement in shelter of hedge; **C** rabbits—food; **D** arable crop seeds—food; **E** hedgerow—nuts, fruit, seeds; **F** boundary of range not crossed—other rats present; **G** rest site en route to farmyard; **H** grain stores etc—food; **I** return to homesite by safest route.
Cat: **1** sheltered sleeping site in shed; **2** prominent places—urine-marked; **3** milk put out by farmer; **4** resting site; **5** farm track - easy access to fields; **6** hedgerow near wood—source of nesting birds; **7** rabbit warren—food; **8** small mammal runs at base of wall; **9** sunning spot; **10** thick hedgerow with small mammals, birds; **11** fence look-out posts; **12** undergrowth sheltering small mammals; **13** pasture with small mammals feeding; **14** resting site in barnyard; **15** road verge—cat scavenges for road-killed animals; **16** resting site; **17** garden of house with female cat—potential mate; **18** dust-bins—food source; **19** feeding site.

delimit their territories and mark them with piles of faeces deposited in shallow scrapes or pits called latrines. Members of a badger clan regularly travel along these boundaries, warding off intruders and depositing fresh faeces in the latrines. Important latrines situated in prime positions along the territory borders are visited at least once a day during the breeding season, whereas less important sites are visited every few days.

Food sources Animals traverse their highways either specifically in search of food or during some other activity, such as dispersal, when they will take the opportunity to feed as they travel. The highways themselves are important sources of food, either directly by animals feeding upon the associated plant materials or indirectly by larger animals feeding upon the smaller animals living among them. Small rodents, for example, sometimes live entirely within a hedgerow, making their runs under the leaf litter and foraging on the invertebrates they find there.

The larger the predator is, the greater the length of field boundary it will patrol in order to find sufficient prey. By radio-tracking feral cats it is possible to follow their hunting excursions. A small radio transmitter is attached to the animal and its movements are monitored by picking up radio signals with a special radio receiver and aerial. A male cat may patrol an area of up to 80 hectares (200 acres) in rural farmland, while a female will only hunt over 10-25ha (25-60 acres). One young male followed on a hunting trip concentrated at least 80% of his activities along field boundaries, moving several kilometres in total but often spending long periods sitting and watching a rodent burrow, waiting for the animal to emerge.

By contrast, a radio-tracked hunting fox travelled about 12km ($7\frac{1}{2}$ miles) in a single night along hedgerows and other field boundaries, catching small rodents and birds, taking fruit and berries as it came across them, and foraging for earthworms in nearby pastures.

Weasels and stoats also concentrate their hunting along field boundaries. Weasels favour dry-stone walls, which they scour for the small rodents living in the crevices, whereas stoats hunt the same prey in their runs among leaf litter and under vegetation. A male stoat travels about 600m (2000ft) during one hunting trip. Brown rats move comparable distances along hedgerows when food is fairly abundant.

The future Very little is known about the overall effect of removing traditional field boundaries, but it obviously eliminates the resident plant and animal communities. For the mammals the impact is unlikely to be catastrophic: few species are confined to field boundaries and the majority can live in alternative habitats. Similarly, many birds prefer a woodland environment but, if no woods are available, they can exploit the field boundary system of hedgerows.

Widespread removal of field boundaries results in isolated patches of habitat with no connecting highways and therefore no connecting immigration or emigration routes. Animals which disperse along field boundaries to new areas would be forced either to stay in their natal ranges or to take greater risks in attempting to disperse across open land. Many animals would be confined to small patches of suitable habitat, unable to colonize new areas, and potential food sources, shelter belts and nest sites would also decrease. Species diversity would therefore decline, and our countryside would be the poorer.

Above: A honey bee on the wing—it is visiting the willowherb for nectar and pollen. Such insects do not travel as far as the birds, mammals, amphibians and reptiles but they, too, use the shelter provided by hedges, banks and walls for nesting, and find food in the plants growing there.

Below: A weasel alert for signs of prey in the shelter of an old wall. Weasels hunt along dry-stone walls for the small rodents living in the crevices.

SPARROWS OF TOWN AND COUNTRY

The house sparrow is a species closely associated with man, sharing his environment and sometimes even becoming a pest. Another less numerous species – the tree sparrow – leads a relatively hidden life in our woods and orchards.

The house sparrow is always seen in close association with man, his buildings and his livestock. It might be possible to describe such an association as 'commensal', except that this would imply some form of mutual benefit, or at least no detriment to either partner in the association. Short of enjoying its presence, we derive little benefit from the house sparrow. The bird, on the other hand, while gaining access to plenty of good nest sites (at no cost to us), oversteps the bounds of commensalism in its attacks on our garden plants. This becomes more serious when it attacks our cereal crops: the sparrow ceases to be commensal and becomes a competitor or, in plain terms, an agricultural pest.

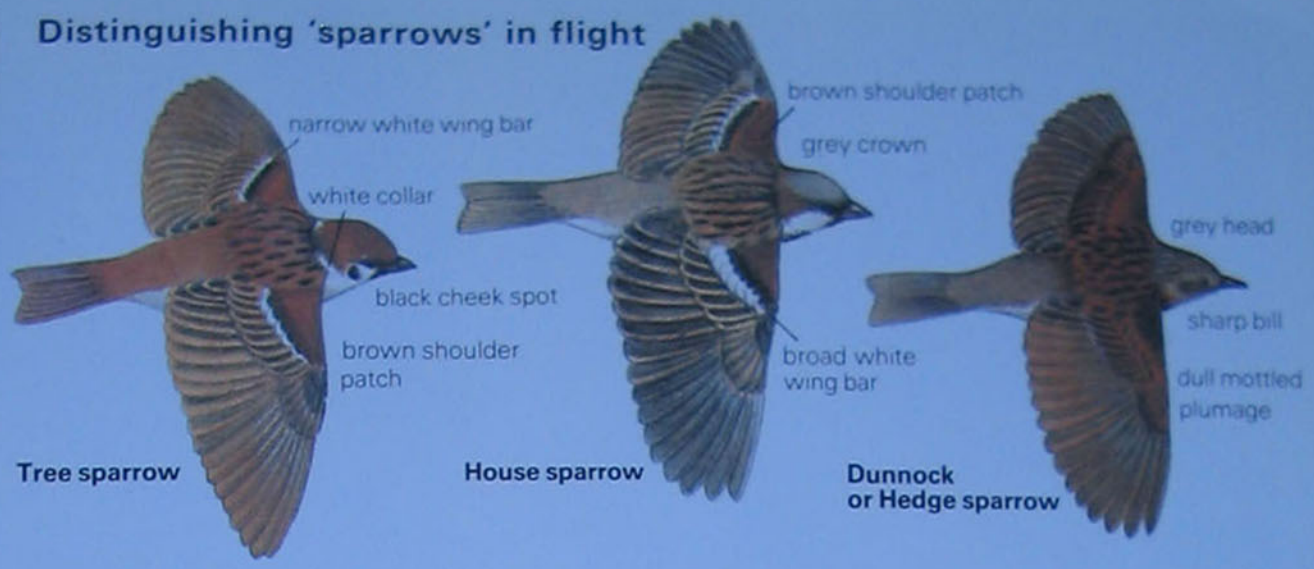
House sparrows are not normally birds of open environments such as hillsides or moors. In the vicinity of farm buildings, however, especially those with livestock, a colony of house sparrows is likely to be present. The birds are also common bird-table visitors, eating almost everything that is put out for them. They even feed on scraps of meat, if it is ever available to them.

Above: The house sparrow's nest, made of coarse grass or straw, is roughly domed.

Below: The male house sparrow (right) can be distinguished from the female (left) by its black bib and grey crown.

Variations in plumage In spring, the male house sparrow is an attractive bird, with a grey crown bordered in rich chestnut brown. His back is a mixture of rich browns fringed with golden buff, his breast is greyish fawn and beneath the chin is a fan-shaped black bib. In winter he is drabber, since many of his body feathers have broad buff fringes which gradually wear away to expose the colours beneath in early spring. The upper plumage of the female (both in summer and winter) is a mixture of sandy or greyish fawns and pale browns, and she is greyish beneath. Until they moult in their first autumn, young birds of both sexes resemble the females.

If you travel about in Britain and Ireland, you may notice that house sparrows living far from towns have much brighter plumage than those living in the industrial conurbations, where the sparrows seem particularly dark. In such circumstances, some species of animals have adapted by changing colour to improve their camouflage. Best known is the peppered moth, normally white with a black peppering of spots. By the process of natural



selection, this moth has gradually evolved darker and darker colours, which improve its camouflage on the grimy trunks of city trees. Recently there was some debate as to whether house sparrows, too, were exhibiting this change (which is called 'industrial melanism'). Samples of sparrows of various shades were examined by experts. A strong superficial correlation was indeed found between darker plumages and more industrialised areas. Washing the feathers of all colour types with strong detergent, however, revealed that the darker ones had been contaminated with soot and other industrial grime, and thus their sombre shades were only 'skin deep'.

Feeding habits The house sparrow is an opportunist feeder, taking what food is easily available in greatest abundance at the time. The diet includes seeds, buds, leaves, shoots, flowers and a huge variety of human food waste and leftovers. Our sparrows are representatives of the largely African weaver-bird family, some members of which are as devastating to crops as plagues of locusts. It is not surprising, then, that our house sparrows flock into the corn at harvest time. Although each bird eats only a few grams of grain in a day, the house sparrow has an extremely wide distribution, and flocks often contain some hundreds of individual birds. The nationwide total of house sparrows is so high that the species is a serious pest, causing many millions of pounds worth of damage each year.

Many gardeners are incensed by house sparrow attacks on their flowering plants. We put out food for them, which they take greedily, only to start to tear apart the crocus and primula flowers when they appear. Although it may be of little comfort to the gardener, there is at least an explanation for this. Notice how often it is the yellow flowers that are attacked. Yellow coloration is associated with flowers that have a particularly strong attraction for pollinating insects, and tends to occur together with a rich supply of nectar. Yellow crocuses, for example, have far more nectar than purple ones. It is this nectar at the base of the flowers that the sparrows are seeking.

Formation of flocks Flocks are very much a part of sparrow life. They are an effective means of exploiting local abundance of food (as in cereal fields) and offer considerable protection from predators. They start to form in late summer, and are often composed largely of juvenile birds. These flocks roam over a distance of several miles. In winter, they join with other species, particularly finches and buntings, on stubble or weedy ground, or around places where livestock are fed.

From late summer onwards, roosting, too, is often communal. Sometimes the roosts are within buildings, and sometimes in the dense shelter provided by rhododendron, hawthorn

House sparrow (*Passer domesticus*). Resident near human habitations. Length 14.5cm (5¾in).

Tree sparrow (*Passer montanus*). Resident in many lowland rural areas. Length 14cm (5½in).

Below: A tree sparrow at its nest site on a cliff. Eggs are laid all through spring and summer, starting in March and continuing into August. Some pairs raise as many as three broods in a season.

Above: A male house sparrow in full breeding plumage.

Below: A tree sparrow in full summer plumage (the sexes are alike). It differs from the male house sparrow in having a brown cap and nape, and a black cheek spot.

or blackthorn thickets, or ivy-clad trees or buildings.

Nesting sparrows House sparrows can be seen around their nest sites in almost any month of the year, though attendance is at its lowest in late summer and early autumn. Attendance remains low through the winter, increasing as days lengthen and the temperature rises. Most nests are under the eaves of houses, or in some other cavity in a building. Some are in haystacks and more natural sites such as crevices in cliffs or in thorny or dense shrubs like hawthorn. Usually, several pairs build nests in a loose colony.

The song of a territorial male house sparrow is a monotonous, repetitive 'chirrup', a familiar noise to us all as he sits close to his chosen site, often adopting a squat, fluffed-up posture. Just as familiar is the sight of the female, perched on roof or guttering, wings drooped and shivering, soliciting the male's attentions. Sometimes there is a communal display, which becomes more and more excited, sometimes even out of hand, developing into a rough-and-tumble chase. Often a single female is the centre of attraction for several males.

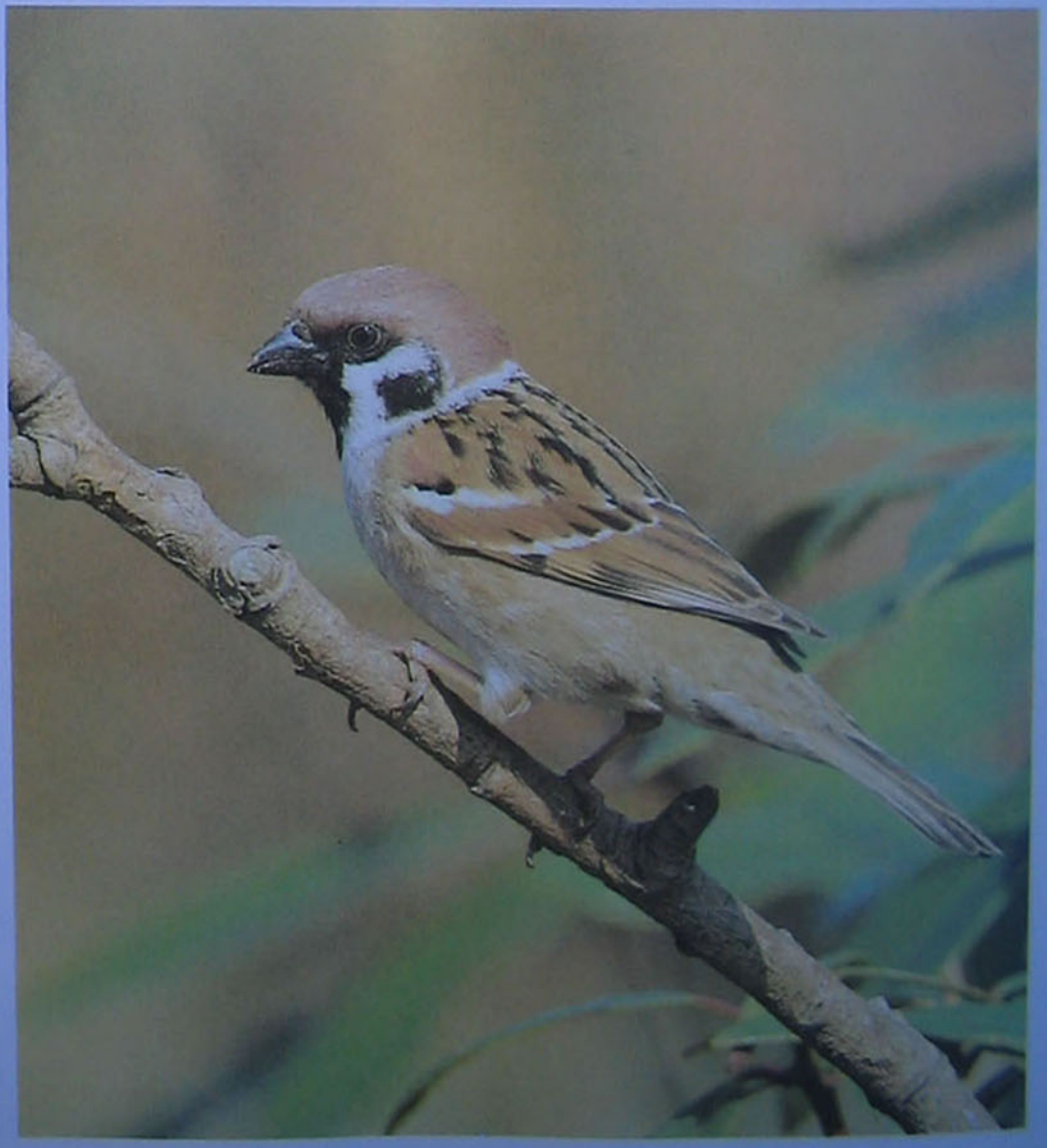
Eggs are laid from March through to August, with each pair attempting two or three, sometimes four broods in a season. Their colours vary from off-white to dull brown, and all are flecked with rich brown. Four or five is the usual number, but clutch sizes range from two to seven. Incubation takes about 12 days, but the time is more variable than in most birds. The young fly after 11 to 18 days, depending on weather conditions and food supply.

The tree sparrow In many ways, the tree sparrow can be considered as the house sparrow's 'country cousin'. It is a slightly smaller, more muscular looking bird, about two thirds the weight of its larger relative. The sexes are similar in plumage; the all-brown cap, the small black bib and the characteristic black spot in the centre of a white cheek distinguish them from the house sparrow. Their call, a rich, fruity chirrup, once heard and learned is an excellent way of separating the two species at a distance or in flight.

Tree sparrows are just as catholic in their food choice as house sparrows, but tend to shun the presence of man, usually feeding and nesting at a distance from human habitation.

The display pattern and the breeding season are closely similar to those of the house sparrow. The tree sparrow lays from two to eight eggs, usually about six, densely flecked with grey-brown. The nest is often in a hole in a building or a tree. In the latter case, the hole may be a natural one, or else the disused nest of a woodpecker. Tree sparrows readily occupy nestboxes, and are pugnacious in their tenancy of them, even evicting other birds such as blue or great tits, and building their own nests on top of those of the first occupiers. Incubation lasts 12 days, sometimes less, and the brood fledges after 10 days, or sometimes more.

Tree sparrows are nowhere as numerous as house sparrows, and have a much less widespread distribution in Ireland, northern and western Scotland, the Shetlands, Orkney and the Hebrides.



WOODLAND ORCHIDS IN THE SPRING

Some of Britain's most beautiful orchids are to be found in deciduous woods. The time of year to go looking for them is the spring, before the trees have had a chance to cast the woodland floor into deep shade with their dense canopy of leaves.

Below: The narrow-leaved helleborine is by far the more attractive of our two species of early-flowering woodland helleborines, the other being the large white helleborine. But it is also the rarer and its numbers are decreasing. The flowers of both species are similar—white petals with the lip marked with several orange-yellow ridges, though the flowers of the narrow-leaved helleborine are always more widely open than those of the large white helleborine.

A woodland habitat, like any other, imposes its own restrictions on the species growing within it. In summer the centre of a dense wood has very few species growing beneath its canopy, simply because the light is not strong enough for most plants to thrive. Nevertheless, many plants do grow in woods. Some survive by flowering early in the year before the trees have developed their canopy; or they may occupy favourable open areas of the wood—the margins or places where trees have fallen or are less closely packed.

Among Britain's orchids there is a small group that is characteristic of woodlands, particularly of beechwoods on the chalk of southern England. Most members of this group flower early in the year, while others grow in clearings and margins. The woodland orchids are at their best in the months of April, May and June.

First to flower The early purple orchid is the first of the woodland species to flower. This is a handsome plant with flowering stems up to 60cm (2ft) tall. The flowers, which are at their best in April and early May, have a three-lobed lip and a blunt spur. The glossy leaves are usually covered in purple-black blotches on the upper surface—an old folk-tale states that these were caused by the blood of Christ dripping on to the leaves, which accounts for its nickname of bloody butcher. (This orchid probably has more local names than any other. Shakespeare noted a West Country one—long purples—which is both more sympathetic and more fitting.)

The early purple orchid is fairly common in many woodlands, although it particularly favours chalky soils.

Lady-like orchid A species related to the early purple orchid is the lady orchid. Seen in full flower through a sun-dappled beech-wood in May and early June this is one of our most striking orchids. Its broad, glossy green leaves surround a flowering stem that may be almost 1m (3ft) high and bears some 25 individual flowers. These have a complicated arrangement of parts that make them look like a caricature of a woman in a long skirt—hence the common name.

Regrettably the lady orchid is not a common species. Its stronghold is the beechwoods of south-east England where, as a result of reasonable maintenance and the fact that it is a protected species, it still occurs in some numbers.

Two twayblades At the same time of year, and in the same habitat, an altogether more modest orchid can be seen flowering. This is the twayblade, its name coming from the pair of large, broad, flat leaves placed opposite each other a short distance up the stem.

Although it is perhaps our most common orchid, many people will not have noticed it in a wood because it is also one of the most inconspicuous of our larger orchids, with dull greenish-brown flowers. This species is capable of growing in deep shade, such as that produced by young pine trees. But, as with the other species, beechwood is its favourite habitat. Occasionally it has been known to grow on chalk downland rather than woodland.

The twayblade has a smaller and even less conspicuous relative, the lesser twayblade. This plant usually grows to only a third of the height of twayblade (20cm/8in) and has smaller, heart-shaped leaves. Like twayblade it is a woodland plant, but its natural habitat is the open pine forests of Scotland. It is a rare species and, because of its size and inconspicuous colouring, much overlooked.

White-flowered helleborines Several orchid species bear the name helleborine, some of which flower early in the year and others later. Two early-flowering woodland species are the large white helleborine and the narrow-leaved (or sword-leaved) helleborine. Both produce white flowers from late May to early June, although the narrow-leaved helleborine finishes flowering a week or so later.

The large white helleborine can grow to a height of 60cm (2ft), with 15 flowers on a stem, though this number fluctuates greatly. The flower segments are arranged to form a tube, which gives the flower the appearance of not having opened out. The lip of the flower bears several orange-yellow ridges. This species tolerates fairly deep shade. For example, it can be found growing on the almost bare ground under a dense tree canopy. It also grows outside woods, where it seems to favour sites under large isolated beech trees.

The narrow-leaved helleborine is a far more attractive plant. Its flower spike is much more distinct from the rest of the plant and its flowers open wider. Both these helleborines are found on similar soils and in similar conditions–beechwoods on chalky soils–yet the narrow-leaved helleborine is becoming rarer. There is no obvious reason why this species should have declined in recent years, but there may possibly be some small climatic differences that have tended

Above: The early purple orchid is the first of the season's woodland orchids to come into flower, in April or early May.

Right: The twayblade is perhaps Britain's most common orchid and it is also one of our most inconspicuous. The flowers have dull greenish-brown petals, apart from the long lip, which is divided into two and usually a bright yellowish-green. This lip is smeared with a trail of nectar. A visiting insect is attracted to the nectar and follows the trail up the lip until it makes contact with the pollinia (the yellow organs shown here). These deposit pollen on the insect's back which is then transferred to the stigma of the next flower the insect visits, thus effecting pollination.

Left: The flowers of the aptly named lady orchid look exactly like a Victorian lady, complete with a bonnet and crinoline skirt. Each flower consists of three flower segments formed into a tight hood, two more segments arranged one on each side of this hood, and finally a large, broad lip in between. Much of the effect comes from the contrast between the purple-brown hood and the much paler lip.

to favour the decline of one rather than the other species.

Butterfly orchids Of all our woodland orchids, the butterfly orchids look most like the exotic tropical species. The greater butterfly orchid is a handsome plant, growing up to 60cm (2ft) tall, with glossy leaves and large white flowers appearing from May to early July. The flowers bear some resemblance to a butterfly, having widespread side petals and a long narrow lip with a long, backward-pointing spur. The presence of this spur, which is full of nectar, and the fact that the flower is at its most fragrant in the evening, indicates that its purpose is to attract evening-flying butterflies and moths.

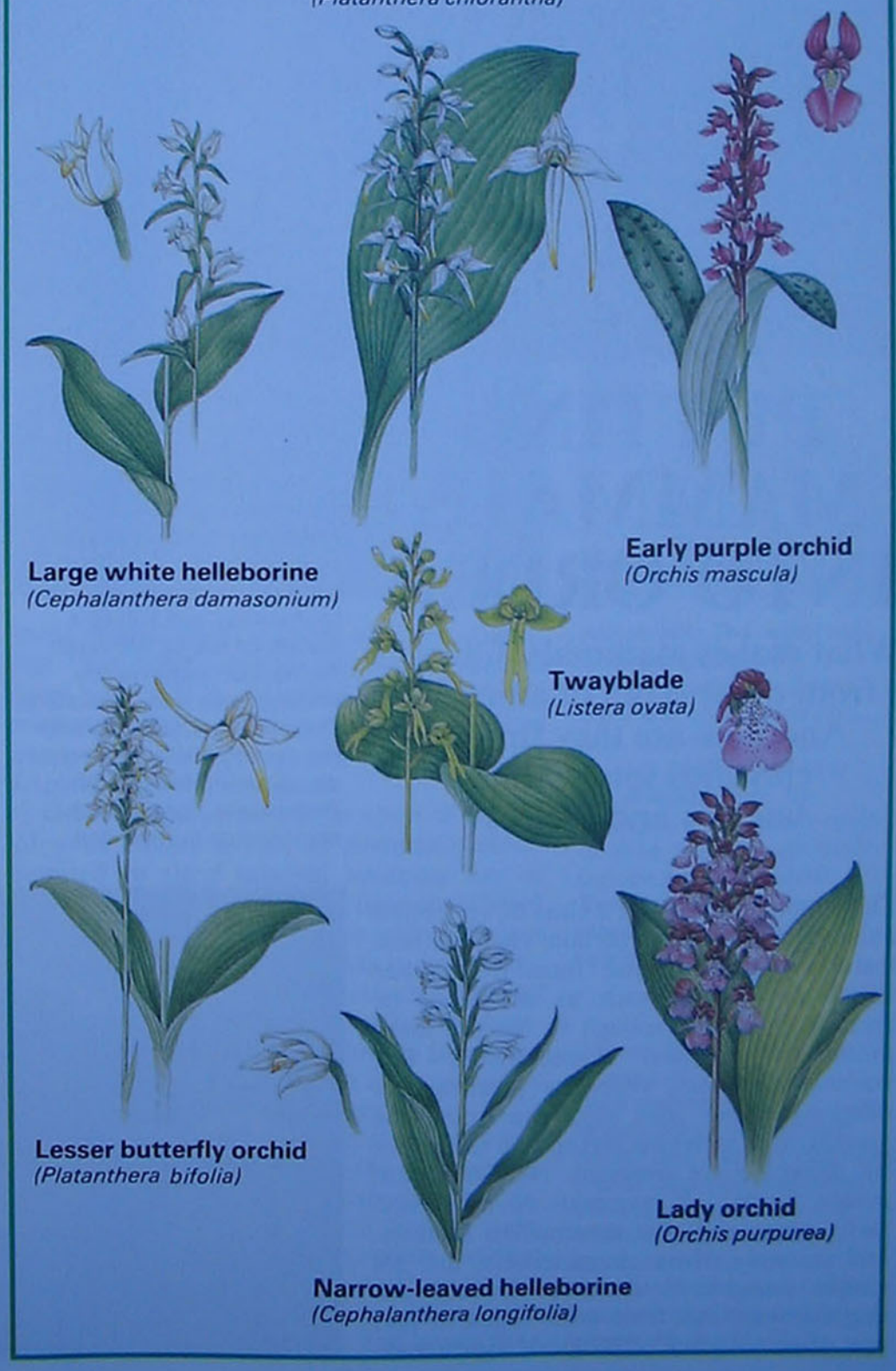
The greater butterfly orchid is a fairly common species in woodland communities. It grows best in oakwoods and does particularly well where the woods are managed by coppicing (a process by which the trees are cut back regularly). Where this is done to a wood for the first time in many years the following spring often reveals numbers of greater butterfly orchids in flower, which until then had remained dormant in the soil. Sadly, however, coppicing and wood management are dying arts because they are too labour intensive and no longer economic.

The other woodland species in this group, the lesser butterfly orchid, is usually a smaller plant and more characteristic of acid moorland. However, it also grows in woods along with the greater butterfly, usually being a larger plant there than in the open and therefore looking very much like its relative. The two species are best told apart by the pollinia (pollen masses) inside the flower. On the greater butterfly the two pollinia diverge away from each other, while on the lesser butterfly they remain parallel.

The future These orchids, many of them rare, face an uncertain future. All can be seen in one comparatively small wood in south-east England. Fortunately it is protected by the local County Naturalists' Trust, so its future seems assured. But other woods are not so safe. There is always the risk that the wood's indigenous trees may be destroyed and replaced by aliens, especially conifers. Worse still, the trees may be grubbed up and the land used for arable or building purposes.

Once a wood has disappeared a unique community dies, and every time that occurs all woodland plants–and especially orchids, which are vulnerable–become scarcer.

Identifying woodland orchids



PUTTING MAMMALS INTO ORDER

What makes mammals different from other types of animals? And how are they further classified into orders, families and species?

Above: The badger, the largest British member of the order Carnivora, which includes most of the truly carnivorous mammals (predators feeding mainly on vertebrate prey). The carnivores are well adapted for hunting and killing a variety of foods, although the badger takes mainly invertebrates and vegetables. The grey seal (below) and the common seal belong to the closely related order Pinnipedia. They too are carnivorous in their diet.

The mammals comprise a class of vertebrate animals which share certain characteristic features that distinguish them from other vertebrate groups, such as the birds or reptiles. It is easy enough to list the more prominent mammal characteristics – fur, warm-bloodedness, viviparity (bearing live offspring rather than eggs containing the young), milk secretion and special teeth – but by doing so we overlook two important points. Firstly, all mammals do not necessarily possess all the mammalian features, and secondly, these characteristics are not simple recognition features to help distinguish mammals from other animals; they are often of vital ecological significance, providing mammals with major advantages over other animals.

Some exceptions The possession of fur is probably the most obvious mammalian characteristic. No other animals are furry. However, pigs and elephants can hardly be called furry, having only sparse hairs; and hippos, whales and a few other more obscure types have almost no hairs at all. Usually the lack of fur is a specialisation for some particular way of life (for example, streamlining in whales, cooling in elephants), but it does mean that fur is not a universal mammalian characteristic.

Similarly, most mammals give birth to babies, but the echidnas and the platypus actually lay eggs. Again, most mammals have two dozen or more teeth, usually of several types (incisors, canines, molars); but anteaters are completely toothless and whales either have teeth of all the same type or none at all. The benefits of warm-bloodedness, too, are temporarily abandoned in some species for hibernation for at least part of their life (these species include the dormouse and the bats in this country).

In fact, if we try to find single features found in all mammals and in no other animals, we have to settle for apparently rather obscure characteristics, such as a four-chambered heart and a lower jaw which consists of one bone each side, rather than several. Ultimately, the secretion of milk is probably the only externally visible characteristic shown by all mammals which is present in no other group.

Staying warm Fur and warm-bloodedness go together; the dense mass of fine hairs which covers most mammals serves to ensure they maintain a high and fairly constant body temperature, despite variable weather. The effectiveness of fur as insulation is most obvious in winter. A mammal's blood temperature is normally 35-37°C (95-98.6°F), yet the mink and the otter, for example, must swim regularly in ice-cold water to catch fish. An inhabitant of wide open spaces, such as the hare, faces an even greater challenge because night temperatures sometimes fall to −10°C (14°F) and a brisk wind makes the

Left: A red-necked wallaby and her young (joey). The wallaby belongs to the order Marsupialia, an order totally separate from all other mammals because its members give birth to a tiny baby which completes its development in an external pouch, not an internal womb, taking milk from the teat which lies within. When it is born the joey has tiny hind legs but big forepaws. It uses these to claw its way through the mother's belly fur to the pouch. The mother licks the fur to smooth it down to make progress easier. The joey makes this first vital journey unaided, even though it is at a stage of development comparable to a three-month old human foetus.

cooling effect even worse. So fur is not just a field-guide recognition feature; it is of great functional importance in helping to keep the mammal's body warm.

Body heat is more than a characteristic of mammals. It also conveys great advantages to them because at higher temperatures all the body processes work faster. Nerves and sense organs function more quickly, allowing speedy reactions; muscles contract faster, permitting greater speed and activity, and digestion is speeded up too. Furthermore, all these processes work at the same sort of rate despite cold or hot weather; cold-blooded animals suffer the inconvenience and limitation imposed by having their range and activities severely disrupted by the weather.

Breast feeding is best Milk is the only food that baby mammals will have for many days or even weeks. A mother grey seal, for instance, produces about 3kg (6½lb) of milk a day, half of it fat and a particularly concentrated source of energy. The cost is high: she uses up to six times as much energy as normal in order to produce it, but the seal pup is able to grow to a weight of over 30kg (66lb) and have its own fat stores before it goes to sea to feed for itself. A female shrew may perform an even greater task: in rearing a litter of five babies she produces, in a few weeks, more than her own body-weight of offspring, built up with only her milk as food.

While the nourishment value of milk is obvious, it has other important benefits too. In many cases the mother uses it to transfer special 'immune proteins' to her babies. These substances act like ready-made medicines in the milk and assist the new-born young to fight off germs. One other interesting benefit is that baby mammals have evolved methods of sucking up milk. This is done using special facial muscles and soft, mobile lips. No other animals have such flexible faces and this is of great value to adult mammals, such as dogs, which use facial expressions to convey 'social messages' of friendliness or belligerence.

Above left: The water vole belongs to the order Rodentia which includes squirrels, voles, mice and rats. Vole teeth have a zig-zag pattern and they are different from, for example, the knobbly teeth of mice. So although both groups are in the order Rodentia, they are classified into separate families.

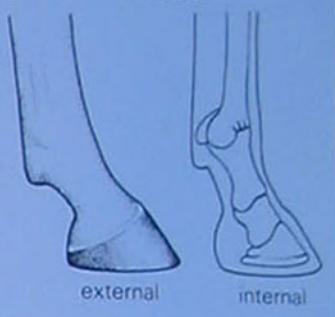
Above: The chisel-sharp incisors of a rabbit. Both rodents and lagomorphs (rabbits and hares) lack canines and have a wide gap (the diastema) between the incisors and cheek teeth. Another lagomorph characteristic is the retracting flaps of skin covering the hairless groove where the nostrils lie.

Other characteristics Even some of the less obvious characteristics of mammals incorporated in their internal anatomy are of functional significance. The four-chambered heart, for example, allows a more efficient blood circulation between lungs and body, permitting higher levels of activity. (Reptiles and amphibians have a less efficient three-chambered heart.) The diaphragm (absent in reptiles) helps pump air into and out of the lungs, again improving efficiency.

The basic ancestral mammal skeleton has been extensively modified in the evolution of some groups to perform specialised functions. For example, forelimbs are formed into flippers in seals and whales, while running mammals such as horses have their fingers developed in the form of hooves, although the rest of the limb (in both seals and horses) has

Left: The fox, the most successful of all British carnivores, survives in all habitats apart from the sea and the highest mountain-tops. It is both carnivorous and omnivorous and is well-known for its opportunist feeding habits.

Odd-toed ungulate eg the horse



Even-toed ungulate eg the deer

Above: A horse hoof and a deer foot: two ways of modifying the basic mammal forelimb to make a hoof for running. The deer's foot is split to spread the weight.

the same basic structure as our own arm.

Similarly, the characteristic dentition of mammals (molars, premolars, canines and incisors) is modified in many different ways to suit different needs. The same basic set of teeth is there–except in the toothless species–but modified for gnawing in squirrels, crushing insects in bats, and catching fish in dolphins and otters. They even form tusks, as in wild boar and Chinese water deer (modified canines) or in elephants and narwhals (modified incisors).

The hair, so characteristic of most mammals, may be lost in some groups or modified to form spines (hedgehogs and porcupines), whiskers, eyelashes, the fluffy tail of a squirrel or even the horn of a rhinoceros.

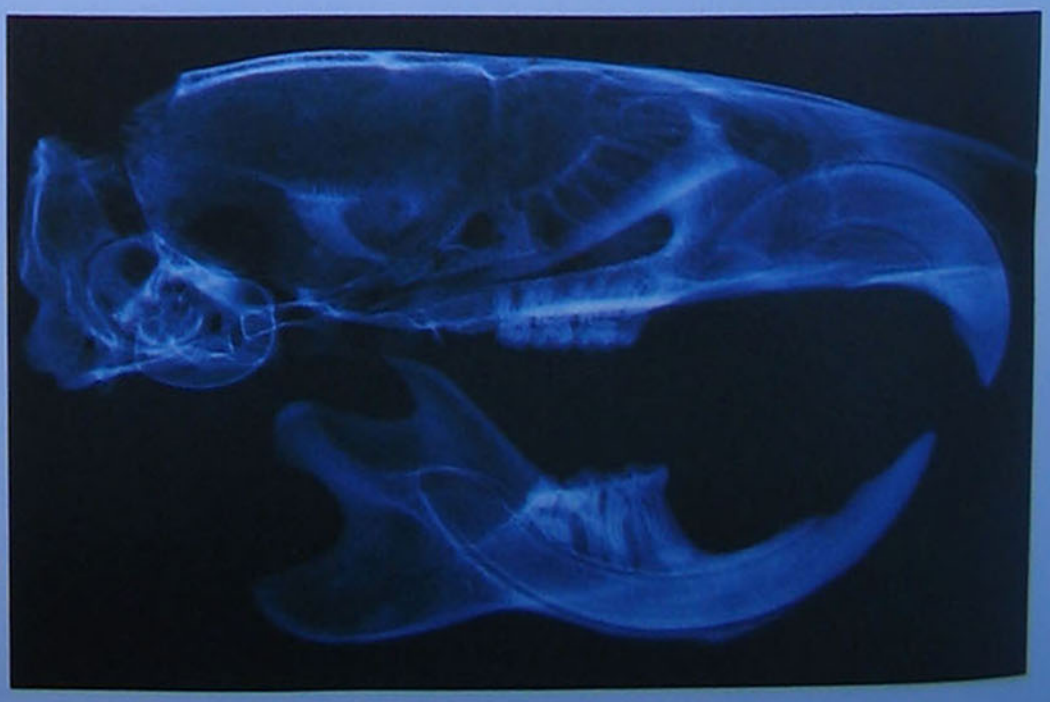
Thus we begin to see a general principle emerging: that mammals have a distinctive basic set of biologically significant features which are modified, or even lost altogether, to suit particular ecological needs and ways of life.

Orderly groups The way in which some of these features are modified, particularly the teeth and the skeleton, forms the basis upon which mammals are sub-divided into natural groups known as orders. For example, all those in which the forelimb skeleton is modified to form a wing are put together in one group: the bats. The two orders in which the forelimbs form flippers, the whales and seals, are separated from each other by the fact that in seals the hindlimbs form propulsive flippers too, but in whales there are no hindlimbs at all.

Two orders of mammals–the lagomorphs (rabbits and hares), and the rodents–have continually growing incisors but no canine teeth: characteristics which distinguish them from all other mammals. They in turn differ from each other in that true rodents have one pair of upper incisors while rabbits and hares have two pairs, one small pair behind the large, chisel-shaped first pair. The carnivores have enlarged canines and the two upper and lower cheek teeth (the carnassial teeth) are specialised for cutting and shearing. The insectivores, on the other hand, have continuous rows of teeth with relatively few pointed cusps. Insectivores also have five clawed digits on each foot, and small brains. Another order, the even-toed ungulates (for example deer) are grouped together because they walk on tip-toe on the equally developed second and third digits of their feet, the remaining digits being reduced.

These orders do not contain similar numbers of species and not all the orders have representatives in the British Isles. This is partly because Britain is an island which land

Below: An X-ray of a rat skull, showing the normal extent of the continuously growing incisor teeth.



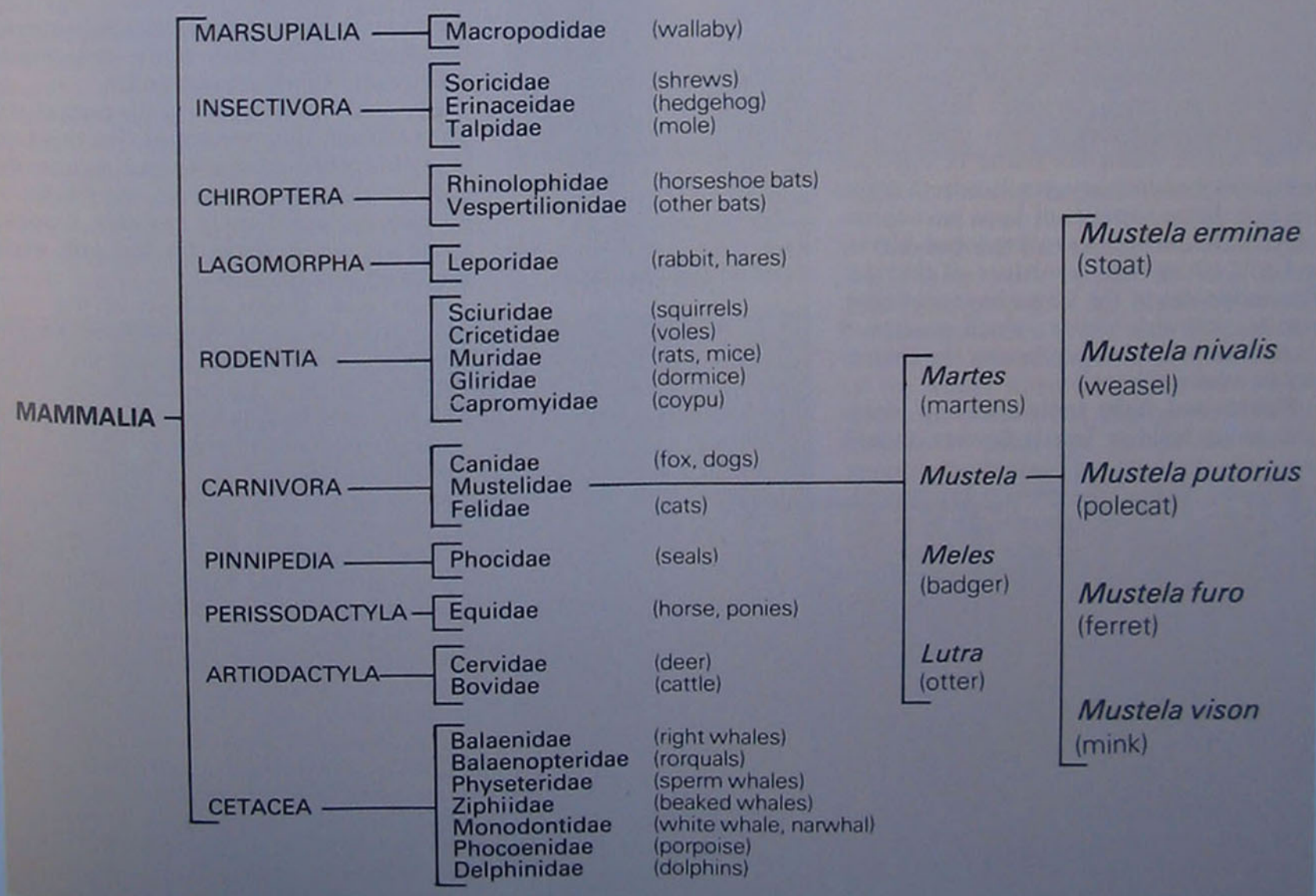
animals are unable to reach easily, and partly because more species live in the tropics than in the temperate regions of the world. For example, even the bats, which could in theory fly to the British Isles, are mostly found in the tropics; only two per cent of their species actually live here.

The British mammal fauna consists of two marine orders (seals and whales) and eight land-based orders. These orders are divided into families of similar species, for example Soricidae (shrews), Leporidae (rabbits and hares), and Sciuridae (squirrels). (Notice that scientifically correct family names are easily recognisable because they always end with *-idae*.) Some families contain only one British species, for example Talpidae (mole) and Erinaceidae (hedgehog), whereas there are several British species in the family Mustelidae, all with similar teeth and body anatomy.

Above: The characteristics of the common shrew, a typical insectivore, include a narrow pointed snout, small, rather ineffectual eyes, short legs, plantigrade feet (it walks on its soles rather than its digits) and shortish, thick, dark fur. Most known insectivores are shrews.

Each mammal species (and other animals too) has a double-barrelled Latin name (like our surname and given name). These species names are usually printed in italics and are recognised by scientists all over the world; even those who do not speak English or even use our alphabet still know that *Mustela erminea* is a stoat, regardless of what they call it in their own language. The first name refers to the mammal's genus, the second to its species. Together the two names identify the species precisely. Some Latin names are helpfully descriptive; for example, the harvest mouse is called *Micromys* (meaning 'tiny mouse') *minutus*–a fitting name for one of the world's smallest rodents.

Mammal classification



HOPS AND BREWING

The native hop plants of our hedgerows and woodlands form an essential ingredient in the brewing of beer. For this they are grown commercially by many farmers of southern England.

The hop (*Humulus lupulus*) is a perennial climbing herb whose bitter flavour is enjoyed by millions of people throughout the world. The use of hops in brewing, however, goes back only about 500 years in Britain; previously many other herbs were used for the same purpose.

In Britain the hop is fairly common in habitats such as hedgerows and the margins of woodland, where its climbing shoots can find support from other plants. From an extensive underground root system, the hop plant produces new aerial shoots each spring. The shoots, called bines, rapidly grow to a considerable height – up to 6m (20ft) – the hollow, six-sided stems spiralling round supporting plants in a clockwise direction. Unlike some other climbing plants, hops have no tendrils with which to grip the supporting plants. Instead, they have stiff, downward-pointing hairs along the ridges of the bines, which perform the same job.

The leaves, which are borne in opposite pairs, are lobed and vary greatly in both shape and size. Some varieties of hops have three-lobed leaves, others have five-lobed leaves, and still others have a mixture of the two. The undersides of the leaves have scattered, minute, yellowish glands, which produce a sticky resinous substance having the characteristic odour of hops.

Flowers and fruits Individual hop plants bear either male or female flowers, though occasionally plants bearing both sexes appear, but these usually have sterile male flowers which do not produce any pollen.

Above: Since the hop is a climbing plant it is grown commercially on a supporting framework of poles and strings, the top of which may be as much as 6m (20ft) above the ground. In Britain the major hop-producing counties are Kent, Sussex, Hampshire and Hereford and Worcester.

Below: Young hop bines growing in spring. From the middle of June to early July a bine may grow as much as 25cm (10in) in a single day.

The male and female inflorescences are quite different in appearance. The males are many-branched structures and occur at the ends of the bines, whereas the female inflorescences are densely crowded, cone-like structures arising from the leaf axils where the leaves join the bine.

Each male flower consists of five small perianth segments resembling petals and five yellow anthers borne on short filaments. The female cones are more complex. Each consists of green bracts arranged spirally around an axis. In the angles between the bracts and the axis are minute cup-shaped flowers, each containing a single ovary with two large stigmas.

After fertilisation the cones greatly enlarge and the glandular hairs surrounding the ovary increase their secretion and produce a yellow resinous powder. When ripe, each hop cone consists of a number of individual ripe fruits covered by papery scales which were once the bracts.

Forerunners of hops Although hops are native to Britain, the ancestors of all the modern cultivated varieties now being grown are thought to have originated in Europe and were introduced here about 500 years ago. Centuries earlier, during the Roman occupation of Britain, hops had been used to

preserve and flavour fermented honey and malt drinks but the practice died out when the Romans left.

During the thousand years up to the 15th century, herbs other than hops were used for this purpose. Most possessed slight antiseptic properties, which were especially valuable in an age when brewing utensils could not be sterilised thoroughly. Ground ivy, a familiar woodland plant, was often used for its antiseptic properties. Alecost and an extract from spruce resin were also used, as was bog myrtle, though some botanists consider the plant to be slightly poisonous. Ginger, dandelion, burdock, sarsaparilla and gentian roots have all been used in beers and some are still popular in soft drinks, though to use gentian roots for this purpose today is inexcusable given the rarity of many species–indeed, it is illegal to pick many gentians.

Beer and ale Strictly speaking, malt drinks made without hops are ales, not beers. The word beer comes from the French 'bière' and only appeared in the English language with the revival of hops in British brewing.

It is often stated that hopped beer became popular in Britain because soldiers returning from the Hundred Years' War of the 15th century had acquired a liking for its taste. An alternative suggestion is that Flemish weavers arriving in Britain during the 14th century brought hops with them. But whatever the reason, hops certainly became popular with British brewers because of their superior preservative properties.

At first there was strong opposition from the public to the use of hops, but slowly they came to be regarded as an essential ingredient in British beer and a great profusion of varieties have now been developed.

About 20 main varieties of hop are now grown in Britain, having been selected for their resistance to fungal, viral and insect attacks, and their ability to 'come into hop' at different times of the year. This ability allows the grower to extend his harvesting season.

Right: Male and female flowers are borne on separate plants. On the female bines each cone-like inflorescence contains many minute female flowers, which are borne in the angle between the green bracts and the central stalk of the cone. The only prominent feature of these flowers is the pairs of long stigmas protruding beyond the bracts.

Below: In late August and September the male flowers release their pollen, which is borne by the wind to the female flowers. Whether or not the females are fertilised, however, they still develop into the familiar hop cones.

Below: As soon as they are picked the bines are passed into a machine that separates the cones from the stems and leaves.

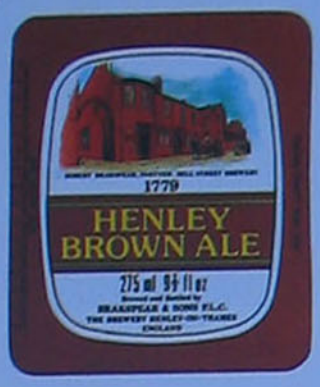
Growing and harvesting Hop plants grow easily from seed, though the hop farmer prefers to propagate his plants by cuttings because cultivated varieties do not come true from seed. The cuttings are taken at the start of the winter when the plants become dormant. In commercial hop gardens various systems of poles and strings are used to support the bines. The soil needs to be well drained and fairly fertile, and the plants need plenty of water during the growing season to encourage the rapid growth of bines.

Harvesting was once done entirely by hand, The hop bines are usually cut off at about shoulder height by a worker on foot, while another worker cuts loose the strings at the top of the bines–he works from a platform on a trailer pulled behind a tractor. The bines are then fed, one at a time, into a machine on the trailer, where the cones are stripped away.

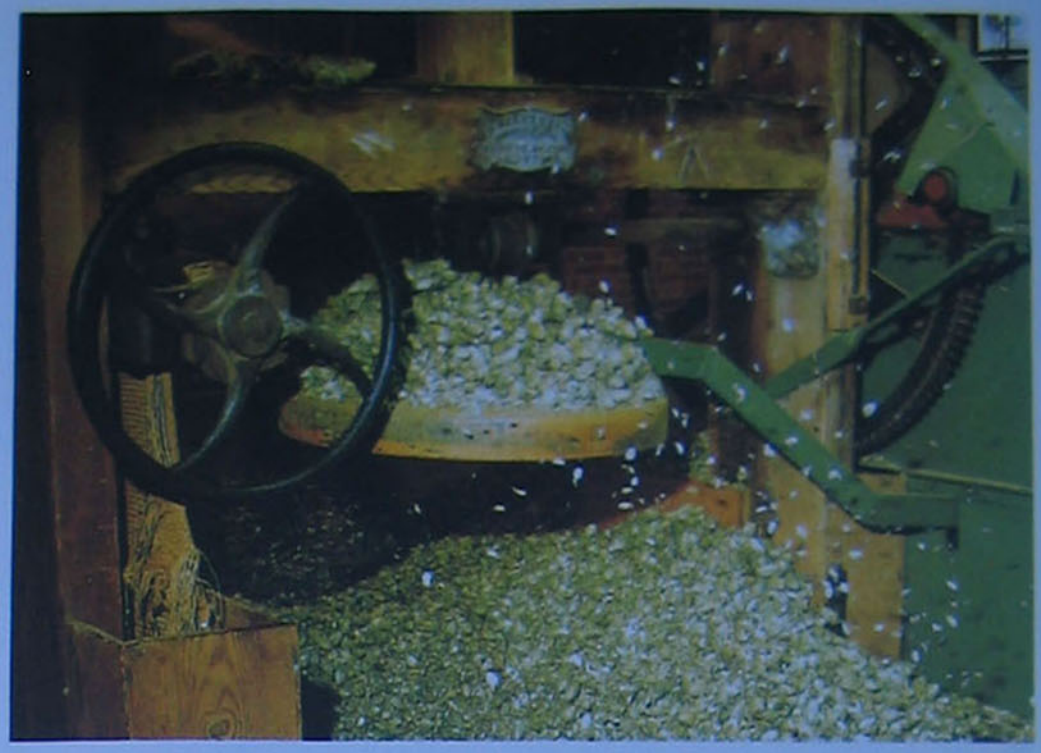
Processing the hops Once the hop cones have been harvested they are dried in an oast house until most of their moisture has been driven off. This must be done as soon as possible after harvesting or else the hops

Left: Samuel Smith's Old Brewery, of Tadcaster in Yorkshire.

Below: Brakspear and Sons plc, of Henley-on-Thames in Oxfordshire.

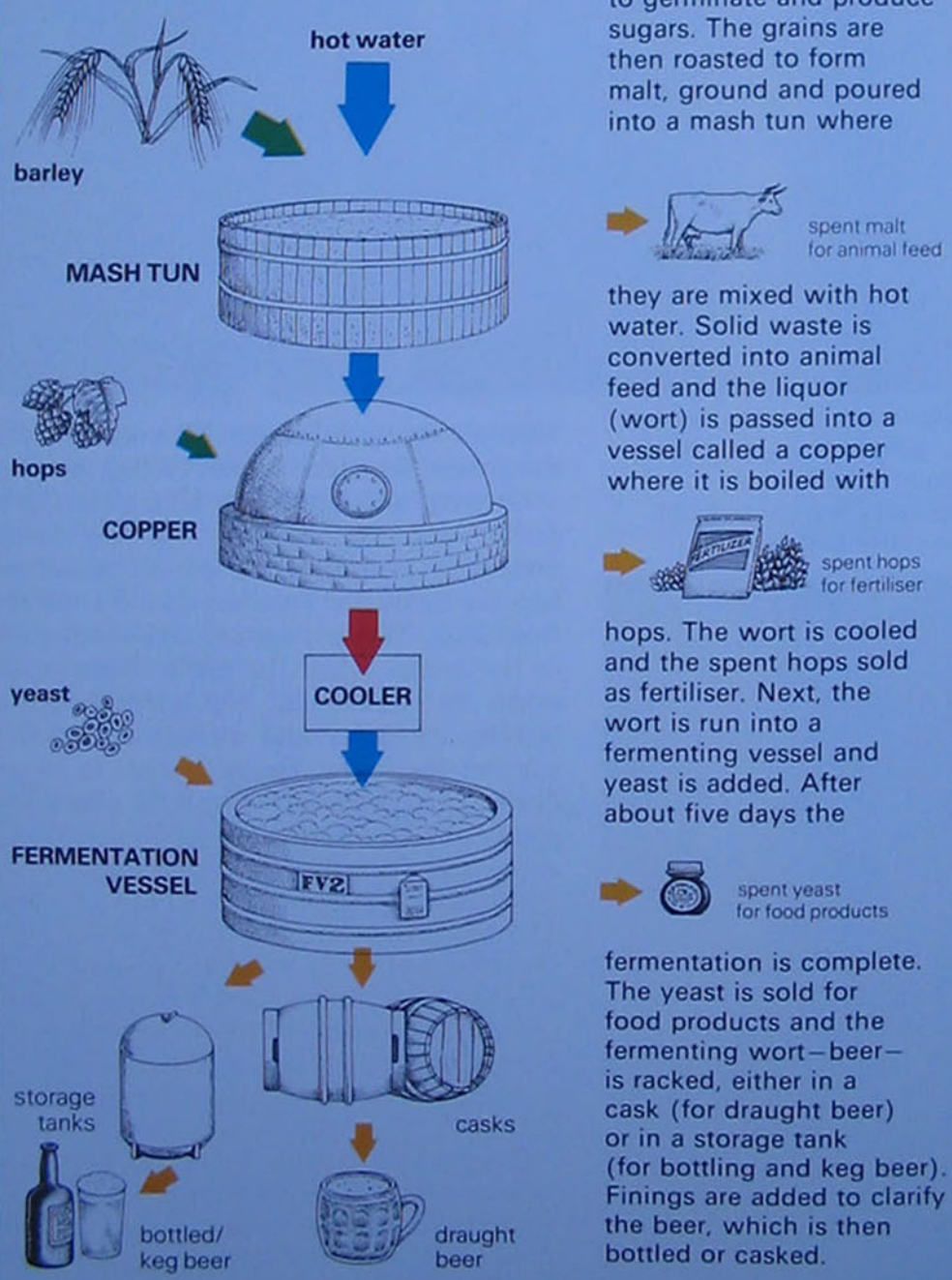


Despite a series of mergers during the past two decades, Britain still has hundreds of local breweries producing beers by traditional methods. Shown here are beer-bottle labels from two such breweries.



Above: Dried hops being packed under pressure into sacks called pockets.

How beer is brewed



Barley is soaked in water, causing the grains to germinate and produce sugars. The grains are then roasted to form malt, ground and poured into a mash tun where

spent malt for animal feed

they are mixed with hot water. Solid waste is converted into animal feed and the liquor (wort) is passed into a vessel called a copper where it is boiled with

spent hops for fertiliser

hops. The wort is cooled and the spent hops sold as fertiliser. Next, the wort is run into a fermenting vessel and yeast is added. After about five days the

spent yeast for food products

fermentation is complete. The yeast is sold for food products and the fermenting wort–beer–is racked, either in a cask (for draught beer) or in a storage tank (for bottling and keg beer). Finings are added to clarify the beer, which is then bottled or casked.

deteriorate. This is why most hop gardens have an oast house near by.

At the start of the drying process sulphur is burned below the hops to give them a uniformly yellow colouring and to reduce the bitter taste that the hops will eventually impart to the beer. After drying, the hops are transferred to a cooling room to allow the remaining moisture in the hops to even itself out through the whole batch. The hops are then packed in large jute or hessian bags called pockets and are ready for marketing.

On the Continent of Europe sulphur burning is not widely practised, which partly accounts for the difference in taste between British and Continental beers. But an even greater difference comes from the fact that British hop growers plant a few male hops in their gardens, whereas Continental growers raise only female plants. Thus in Britain, female hops are fertilised, but not those on the Continent, and the fertilised flowers produce a more bitter flavour because the glandular hairs within the flowers are much more active after fertilisation than before. Also, Continental beers usually contain only a third of the amount of hops in British beers.

Brewing beer The yellow resinous powder produced by the female flowers is responsible both for the hops' preservative properties and for their bitterness. This sticky resin can be felt by rubbing a few female cones between the hands.

The resin is extracted from the dried flowers by boiling them with wort–the sugar-rich liquor extracted from malted barley. When the wort has cooled, yeast is added and fermentation begins. Once the beer has cleared it is transferred to bottles or barrels and, in the case of the latter, a handful of hops is placed in each barrel before the beer is added. These hops help in the final conditioning of the beer, contribute to its bouquet and also account for the occasional hop bract which finds its way into a glass of beer.

BLACK-HEADED GULLS: LIVING OFF THE LAND

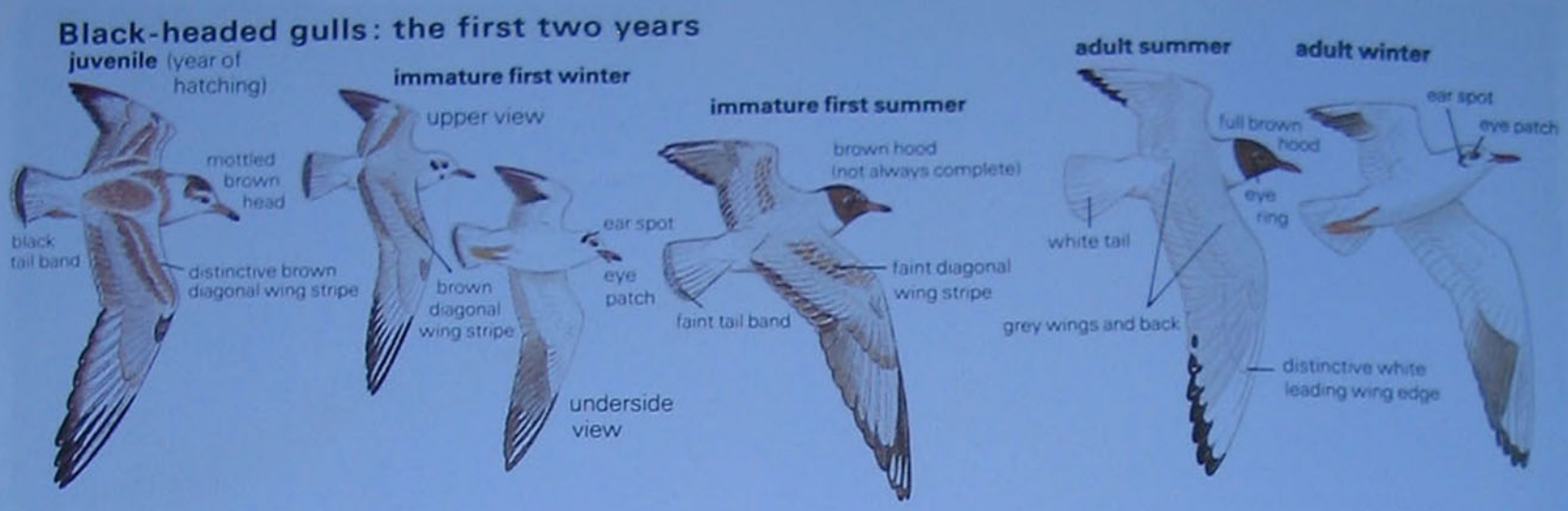
The black-headed gull – its head is in fact chocolate brown in summer and mainly white in winter – forms breeding colonies inland more often than on the coast. Thus it is so often seen that it appears to be our commonest gull, despite the fact that the kittiwake and the herring gull are both more numerous.

Above: Black-headed gulls leaving the colony briefly in a mass flight known as a 'dread'. This is thought to be a part of the process of mutual stimulation, which ensures synchronised egg-laying. This increases security, for the colony is at its most vulnerable when the chicks are young.

Below: A black-headed gull chick. Still unfledged, it is largely dependent on its parents.

Since the beginning of this century, the black-headed gull has increasingly become a terrestrial, even agricultural, bird rather than a marine one. Although several gull species follow the plough, it is the black-headed gull that is most often seen forming lines of squabbling birds competing with one another for worms in the fresh-turned furrows behind the tractor. In some places it could now even be described as an urban species, so frequently is it seen in winter on playing fields and rubbish dumps.

Changing plumage The variety of black-headed gull plumage is such that it often causes confusion. The 'black' head is in reality chocolate brown, forming a hood



Below: Black-headed gulls roosting in a car park in winter. Even in the urban habitat, they can find spaces giving a clear view of any approaching danger.

stretching down the nape and broken only by a white ring round the eye. It is seen only in summer; at this time, the beak, legs and feet are a deep blood-red, contrasting with the impeccable silvery white plumage of the body. The wing-tips are black, with a triangular shaft of white along the leading edge of the primaries (a most useful characteristic for identification purposes).

This white leading edge remains as a good field character in winter, when the brown hood is lost and replaced by a small grey-brown smudge behind the eye. In winter, the beak and legs are a much muddier red while the beak usually has a black tip. Sometimes the hood may start to reappear shortly after Christmas, so intermediate stages are frequently seen.

Young birds, when they leave the colony, share the small size and relatively delicate shape that help to separate black-headed from larger gulls. Seen from above, when in flight, the young birds have a distinctive diagonal brown stripe across the inner half of the wing, giving a 'W' pattern.

The specific name of the black-headed gull is *ridibundus*, which means 'laughing'. This is derived from its summer calls, which are varied forms of laughing yelps. Some are long and drawn out, others short, but all are detectably higher-pitched and less harsh than those of the larger gulls.

Widespread species No birdwatcher should have difficulty finding black-headed gulls: during winter they are widespread both on the coast and inland over much of Britain and Ireland. At this time of year our own birds are augmented in numbers by many thousands of black-headed gulls from the Continent, escaping the harsh winter in northern Europe. In summer, too, they are more widely distributed than the other gulls, with many inland colonies. With a breeding population estimated as numbering between 150,000 and 300,000 pairs, black-headed gulls are not as numerous as herring gulls or

kittiwakes; but their distribution both inland and on the coast ensures that they are the most commonly seen gulls in summer and winter alike.

Location of colonies The species breeds in a broad belt right across western, central and eastern Europe and into the Far East. In Britain and Ireland, colonies in the south tend to be near to the coast, and in the north they tend to be both coastal and inland.

Although the black-headed gull is always a colonial breeder, the sizes and sometimes the locations of the gulleries vary considerably from year to year. The commonest coastal sites are among sand dunes and on saltings, or on islands in estuaries; inland, typical sites are beside lakes and moorland tarns on boggy ground, often at a considerable altitude.

More recently, black-headed gulls have begun to exploit a range of man-made sites, particularly those resulting from mineral extraction where subsequent flooding has left a series of exposed islands. Other colonies can be found on sewage farms.

Colourful courtship Black-headed gulls begin to reassemble in their colonies in March and April. During winter they show a preference for wide open spaces with a clear view of approaching predators, but at the start of summer they begin to look for areas with sufficient ground cover to conceal nests and young.

Within the colony, males establish small territories, and strike an aggressive pose if any other bird approaches. This is followed by a 'stretching' posture, in which the male tries to appear as tall as possible. He turns his brown-hooded head towards the intruder, pointing his beak downwards in defiance. Accompanying this behaviour are head movements ('flagging') which emphasise the contrast between the white nape and the brown face as the head is suddenly turned sideways.

Such measures usually serve to frighten off a male intruder without actual strife, and help to space out nests so that there is adequate room for the broods. The response of an intruding female differs: although partly frightened, she is driven on by greater sexual urges, and continues to approach. Gradually she adopts a submissive, head-down posture. Once she is accepted, the courtship ritual continues with both sexes making vigorous head movements simultaneously ('head tossing'). The male leads his female to a nest site which he has chosen in the territory, and there the pair build a nest.

Raising the brood The usual number of eggs is three, but one, two or four are sometimes laid. The usual colour is olive green, with darker blobs, but in any large colony a range of colours is likely to be encountered, from pure sky blue to almost black. Incubation lasts just over three weeks, with the sexes sharing the duties, and the youngsters take about five weeks to fledge. The birds usually raise one brood per season.

The young hatch covered in down, with their eyes open. The down is yellow, with brown camouflage markings, and the young remain in the nest for a day or two before moving off to shelter under nearby vegetation. They emerge when a parent returns with food.

With such a variety of gullery sites, food for the young varies from place to place. In many areas, insect larvae and earthworms feature prominently in the diet. Elsewhere, the young are fed on gleanings from rubbish tips, fish or fish offal, small crustaceans and other marine animals.

Above: Nests vary from little more than a saucer-shaped scrape in the ground to a substantial pile of grass, reeds or seaweed. The cup itself may be up to 50cm (20in) above ground level.

Black-headed gull (*Larus ridibundus*). Resident small gull; widely distributed. Length 36-38cm (14-15in).

Below: At the time of courtship, the two birds perform ritualised head-shaking displays to strengthen the pair bond.

HEBRIDEAN MACHAIR

In the Hebridean Islands, particularly North and South Uist, can be found the machair – an extremely localised land form consisting of a shell-sand based (and therefore lime-rich) stable grassland that is exceptionally rich in wild flower species.

The highlands of Scotland usually bring to mind wild, heather-clad hills populated by golden eagles and red deer, but less than 80km (50 miles) west of the mainland highlands lies the archipelago of the Outer Hebrides, comprising well over a hundred islands. The largest are Lewis, Harris, North and South Uist, Benbecula and Barra. While the eastern sides of these islands show their connection with the mainland hills, the western seaboard, especially from North Uist southwards, is in brilliant fertile contrast to the acid moorland. Waves rolling in from the Atlantic break endlessly against long, white, shell-sand beaches, behind which lies the Hebridean machair – stable grassland

Right: The longest and best developed stretches of Hebridean machair are to be found on the western seaboard of the islands of North Uist and South Uist in the Outer Hebrides. On these two islands there are estimated to be over 6000ha (15,000 acres) of machair land. Machair also exists on the Inner Hebrides, Orkney, Shetland and the northernmost mainland of Scotland, but not to the same extent as in the Uists. By contrast, the eastern seaboard is hilly.

Left: Wild flowers are a feature of Hebridean machair; the harebell is one of the characteristic species.

Previous page: Shell-sand beach at Seilbost, Harris.

Below: Stooked corn on machair, South Uist. Ploughing on machair takes place late, in April, traditionally with a shallow-bladed plough which turns a narrow crested furrow. Harvesting, too, is late, little being cut before September, and even then the grain may be green in the ear. The smaller areas may be cut by hand, but the usual method is by binder-reaper, a piece of equipment hard to obtain in Britain nowadays. The sheaves are put together in stooks to dry, after which they are collected together into ricks, either on the machair or adjacent to the croft buildings, and well tied down against the winter storms. Threshing either takes place during the winter or the grain is fed to the livestock in the sheaf. However, the livestock animals also tend to help themselves from the ricks. This, together with damage to standing and stooked grain from wild birds, especially greylag geese, means that the harvest is often a scanty one.

based on the shell-sand and supporting an abundance of wild flowers.

Machair formation Machair has developed in areas greatly exposed to north and north-westerly winds which, since they are inevitably salt-laden, play a considerable part in determining the flora. With the annual rainfall exceeding 1000mm (40in), the climate is cool and humid but comparatively mild.

The exact method of machair formation is unknown, but it has been suggested that the basis was the erosion and re-deposition of broad, high coastal dunes over a long period of time, probably beginning almost 6000 years ago. The long, high back-slope of these dunes was eroded out to the water-table and the sand re-deposited landward. Initially the point of erosion was just behind the dune summit, but the dune scarp forming the point of erosion gradually moved eastwards too. In some cases re-deposition was on firm ground, in others it was in depressions formed by lochs and marshes. Where these were sufficiently shallow, organic soils formed. The end product was the shell-sand grassland as we know it now.

The lime content from the shells gives the soil its fertility and lightness; in some places the calcium carbonate content of the sand is over 80%. The plain is up to 1.5km (one mile) wide, low-lying (usually less than 5m/16½ft above mean sea level), and has an extremely gentle gradient. It floods during the winter.

The method of formation means that if one walked in a straight line from the west to the east coast one would pass through a succession of habitats which, in the classic situation, run parallel to the coast. Moving inland, these are: open shell-sand beach, dune, dry machair, wet machair, marsh and fen, eutrophic (nutrient-rich) loch, blackland (acid moorland improved by adding shell-sand), and moorland with myriads of acid lochs. (The townships are built on the blackland.)

Agriculture on the machair Because of its relative fertility, the machair is the most important part of the croftland for agriculture. It is seasonally grazed by both cattle and sheep, although for much of the year the sheep are on the moorland hills. In the past the blackland was extensively cultivated but the dry machair is the main area cultivated today. Each croft, or small farm, has an associated area of the township machair, which is cultivated in strips on a rotational basis. The length of this rotation varies from township to township; in some a strip is cultivated for two years and left fallow for two years, while in others the rotation is over three years, or some other combination. The important consequence for both plant and bird life is a closely integrated mosaic of small strips of cultivated and fallow land forming a very diverse habitat.

The main crops are cereals–small oats, rye, bere (barley)–and potatoes, but in recent years there has been a marked decline in the cropped acreage. Traditionally seaweed, mainly *Laminaria* species, cast upon the shore during winter gales, was used as a fertiliser. Latterly chemical fertilisers, which put no organic material back into the soil, have been used.

Above: Arctic terns breed regularly in the Outer Hebrides. They frequently nest on machair.

Below: Harebells, red clover, ragwort, daisies, buttercups and wild carrot on machair.

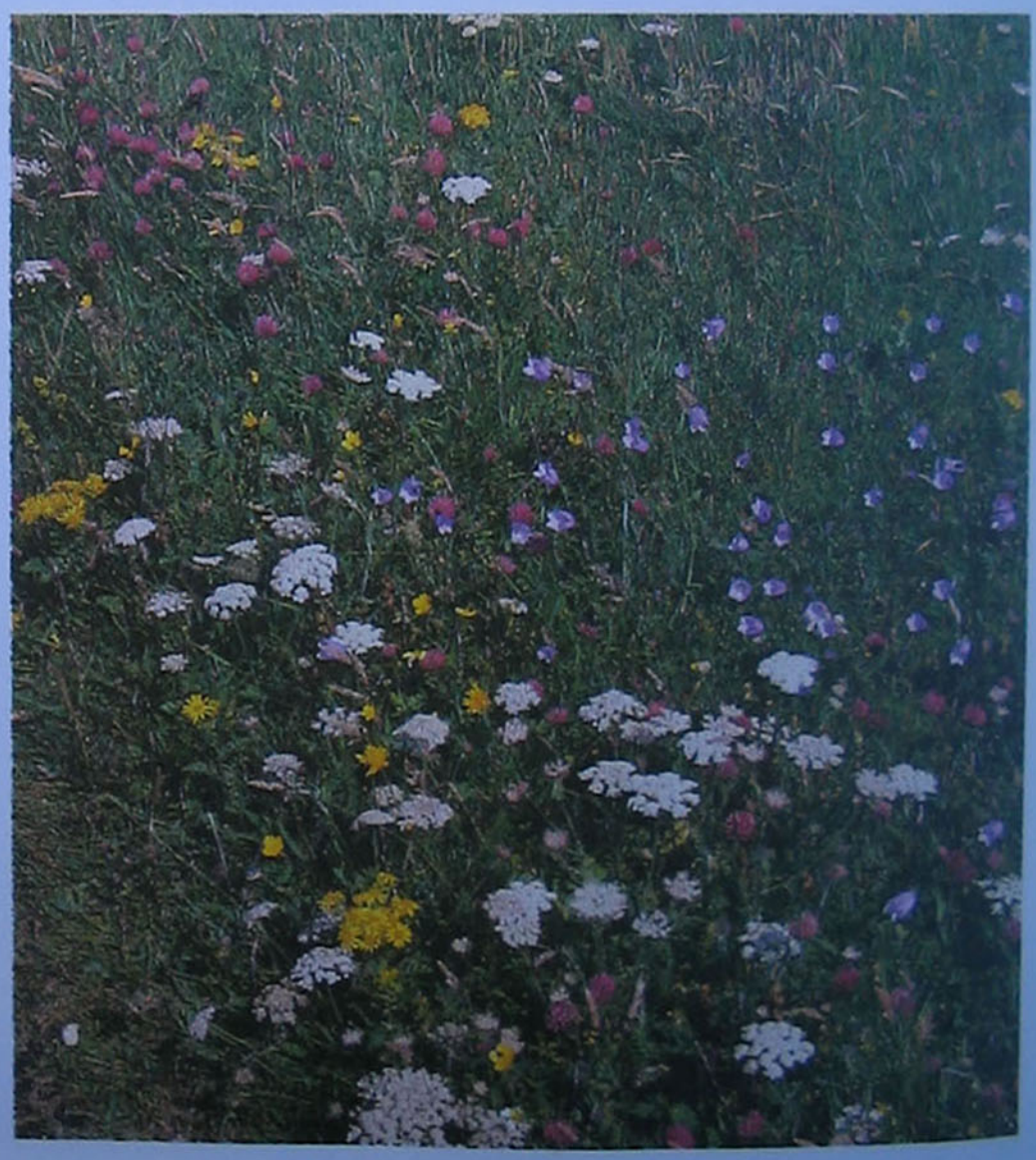
The flowers of the fields After the long, wet and windy winter, spring comes late to the Outer Hebrides, with little plant growth prior to May. However, by mid-June the contrast is complete for the machair is then at its best–a magnificent sight ablaze with colours of virtually every hue. Most machairs contain similar plant species: dove's-foot crane's-bill, common stork's-bill, red and white clover, bird's-foot trefoil, daisy and harebell are all widespread, together with many more species. In addition to the diversity, the sheer abundance of the flowers is breathtaking for those accustomed to modern monoculture farmland. On the machairs of the Monach Isles alone, off the west coast of North Uist, about 220 species of flowering plant have been recorded. The individuality of a machair is brought about by the dominant species; one of the most famous is that at Eoligarry in Barra, where the dominant species is the primrose. Here primroses carpet the ground so closely that it is difficult to walk without treading on them.

One of the most fascinating aspects of such rich grassland is the changing of the flowering sward as the season progresses. The red of crane's-bill and stork's-bill, together with the yellow of bird's-foot trefoil, are among the first to appear. The latter is replaced in mid-July by lady's-bedstraw which, in parts of South Uist, can be so dense as to recall the colour of an old buttercup meadow. Among the later flowers are the blue harebell and the whitish-purple eyebright.

Some plants, especially those on arable land, are scarce on the mainland as a result of the pressures of modern farming. In few places are corn marigolds and bugloss still as common as they are on machair. In late summer corn marigolds can be found on both fallow and arable land and, in places where there is little control by herbicides, they may be the most frequent weed of cultivated areas.

Winter feed for stock is an important commodity in the Uists and many of the damper machairs are cut for hay. Some of the meadows have been re-seeded in the recent past with agricultural grasses, but a number of natural hay meadows still remain. Here again, the floral richness is impressive. Ragged robin, buttercups, red rattle, clover, even horsetails and several species of orchid, make a startling comparison with the uniformity of agricultural grasses normally cut for hay elsewhere. On the mainland many of the ancient hay meadows still existing are jealously guarded and managed to maintain their interest, often as Nature Reserves.

Wetland flowers Orchids do occur in some of the lower lying areas of dry machair, but they grow most profusely in the damper areas. Early marsh, northern marsh, common twayblade, frog and the speciality of the Hebrides, the Hebridean variety of the common spotted orchid, are all widespread. In common with many Hebridean plants, one of the characteristics of the Hebridean spotted orchid is its diminutive size (15-30cm/1-12in high) compared with its mainland counterpart. It is also stockier than the typical variety, with darker flowers and more heavily spotted leaves.



At the edge of the eutrophic lochs these wet grasslands may merge into fen communities dominated by reeds, bulrushes, club rushes, marsh marigolds and marsh cinquefoil. The deeper open waters also support luxuriant vegetation, which forms rich feeding grounds for wildfowl. Close to the coast many of these lochs are under maritime influence, resulting in the formation of saltmarsh at the loch edges. This grades into the wet machair. On such a sandy substrate the saltmarsh tends to be species-poor – a sward of thrift associated with sea milkwort and sea plantain, sometimes with 10cm (4in) high sea aster. Parsley water dropwort and brookweed are among the scarcer species which may be present.

Birds of the machair The biological interest of the machair cannot be measured in terms of the plants alone. The wealth of birdlife is just as remarkable. As with the plants, the birds are best seen in spring and summer. Although many waders and gulls frequent the Outer Hebrides during winter, they spend most of their time feeding among the seaweed on the beaches. From February onwards the machair becomes increasingly alive with the displays, songs and alarm calls of the birds moving back on to their breeding grounds. Probably the most important of these, and the ones for which the Outer Hebrides are most famous, are the waders – oystercatchers, ringed plovers, dunlin, redshank, lapwing and snipe.

The most important species of the dry machair is the ringed plover, with over 850 pairs nesting in the Uists and Benbecula. This is far more than in any other county in Britain and represents about 14% of the entire British and Irish breeding population.

The scarcest of the breeding waders is the red-necked phalarope, a bird that frequents marshy, heavily vegetated lochs. At the turn of the century there were probably at least 40 or 50 pairs in the Outer Hebrides, but now there are only one or two pairs.

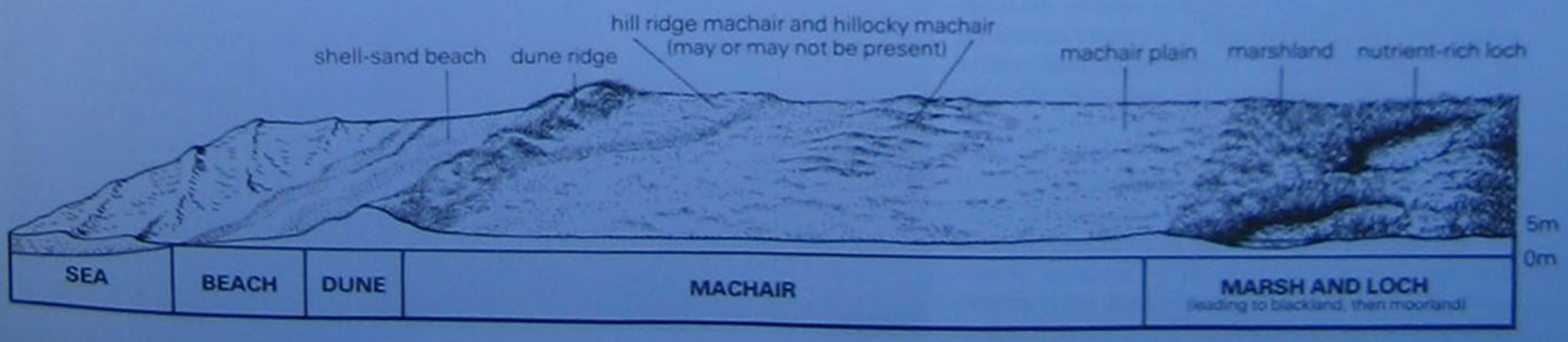
Another scarce bird found on the Hebridean machair is the corncrake. Like the red-necked phalarope, it is strictly protected by law; it is illegal to disturb either species during the breeding season. Only two or three decades ago the corncrake was widespread and common on the mainland both in Scotland and England. Now it is virtually restricted to the Hebrides and Orkney.

Above: Eyebright on Lewis. Eyebrights are small plants, but throughout the machair they compensate for their lack of size by their abundance. Common eyebright is the usual machair species, but another nine have been found to date in the Outer Hebrides, including some rare and endemic species.

Below: Running parallel to the coast, from west to east across the machair islands, is a succession of habitats: open shell-sand beach, dune, machair, marsh and fen, eutrophic (nutrient rich) loch, blackland (acid moorland improved by the addition of shell-sand), where the townships are built, and moorland with myriads of acid lochs.

The future The machair is a product of the land, the climate and man, but it has evolved under traditional land use practices, without the rigours of modern agriculture, its equipment and its chemicals. The wealth of plant and bird life openly reveals this, but agriculture in the Outer Hebrides is recognised to be in a very poor state. Currently, grant aid from the EEC and Britain is being made available through an Integrated Development Programme. Among its aims is land improvement, including the improvement of machair and blackland. It cannot be denied that certain facets of the Hebridean economy require financial help, but undoubtedly the survival of the natural environment in the islands as we know it requires a balanced interpretation of the needs of both modern man and wildlife.

Characteristics of the machair



Left: Willughby's leaf-cutter bee (*Megachile willughbiella*) holding a leaf while it cuts out a piece with its sharp, powerful jaws. Rose leaves are particular favourites.

Right: The mason bee *Osmia bicolor* collecting earth for its cells, which are constructed in empty snail shells.

Pollen-carriage

underside of abdomen
Megachile willughbiella

The leaf-cutter bee's pollen brush or scopa, consisting of stiff rows of bristles, is situated on the underside of its abdomen (most bees carry pollen on their hind tibiae). The scopa may appear orange, because of the mass adhesion of dry pollen grains, although the hairs are, in fact reddish.

SOLITARY BEE SPECIES

Apart from colony-forming bees, a number of solitary species exist, including the leaf-cutter (renowned for the damage it causes to roses), the mason and the wool carder bees.

Have you ever noticed circular or semi-circular pieces cut out from rose bush leaves in July and August and wondered what causes this disfigurement? It is the work of leaf-cutter bees, two species of which are common in our gardens—the patchwork leaf-cutter (*Megachile centuncularis*), and the slightly larger Willughby's leaf-cutter (*Megachile willughbiella*).

Leafy burrows Leaf-cutters are solitary bees maintaining their own small nests in burrows in rotting wood, using either old beetle borings, or excavating new tunnels themselves. These burrows are lined with pieces of leaf cut by the females from rose bushes. The leaf pieces are stuck together with saliva to form cells, normally six to ten in each burrow. One egg is laid in each cell, which is stocked with food in the form of a semi-fluid mixture of pollen (providing the protein) and honey (supplying the carbohydrate) for the larva.

On hatching, the larva takes two to three weeks to become fully grown. It then spins a papery brown cocoon in which it remains as a larva until the following spring, when it pupates, emerging as an adult bee in June.

An interesting feature is that, although all the cells contain fully developed bees, the adults emerge only one at a time, those in the outer ones first, in strict order. The outer

Left: An exposed leaf-cutter bee's nest showing the leaf cells and the newly hatched larva. The bees build their nests in burrows in rotten wood, either using ready-made holes or digging tunnels themselves. The female does all the work, cutting large pieces of leaf for lining the tunnel. She uses about a dozen pieces for the walls, overlapping each one and then gluing the edges with saliva; smaller, circular pieces are placed on the cell floor. She then fills the cell with food for the larva, and lays an egg, before finally closing the cell up, and starting on the next one. Between six and ten cells are built in each tunnel.

Right: A rose branch devastated by the work of leaf-cutter bees.

Above: Patchwork leaf-cutter (*Megachile centuncularis*), 12mm ($\frac{1}{2}$in) long. Common in gardens on roses and Virginia creeper.

Above: Willughby's leaf-cutter (*Megachile willughbiella*), 13-15mm ($\frac{3}{5}$in) long. Occurs commonly in gardens on roses.

Above: Red mason bee (*Osmia rufa*), 10-14mm ($\frac{1}{2}$in) long. Common in most parts of Britain, where it nests in walls and posts.

Above: Two-coloured mason bee (*Osmia bicolor*), 10mm ($\frac{3}{8}$in) long. Found in limestone and chalk areas, nesting in snail shells.

Above: Wool-carder bee (*Anthidium manicatum*), 15mm ($\frac{3}{5}$in) long. Commonly found in gardens on such flowers as dead-nettle.

cells all contain males, while the inner ones are occupied by females–this is believed to lessen the chances of brother and sister mating.

Transporting pollen The adult bee looks somewhat similar to the honey bee at first sight, but closer inspection reveals that it has a different outline with a larger head to accommodate the big jaws–used for cutting the leaves–and an upturned, square-ended abdomen. The abdomen is shaped in this way to accommodate stiff rows of bristles situated on the underside of the segments, forming a pollen brush or scopa which is used for carrying pollen.

This kind of scopa is found only in leaf-cutter bees and their immediate relatives. The majority of bees carry their pollen either in a scopa on their hind tibiae (mining bees, for example) or in a pollen basket or corbicula, a wide bare area margined with long hairs on their tibiae, as in the case of bumble bees and honey bees.

All bees remove the pollen from their body hairs by using special brushes situated on their tarsi, and then store it, either dry in the scopa, or moistened with nectar on the corbicula (when it loses its orange colour).

The leaf-cutter bees appear to prefer gathering pollen from the more open flowers, such as large campanulas, or flat-topped flower heads. They can often be seen in gardens, wallowing in such flowers–an action which helps pick up the pollen.

Parasites In common with so many other industrious insects, leaf-cutter bees have their attendant parasites–in particular bees of the genus *Coelioxys*. These are recognised by their pointed abdomens, which lack a scopa.

The parasites slip into the leaf-cutter bee nests when the owners are away, and plunge their own eggs deep into the pollen mixture, so that when their larvae hatch they consume both the food stores and the leaf cutter's eggs or young larvae.

Mason bees The mason bee (*Osmia rufa*), common in most parts of Britain, is not unlike a leaf-cutter in appearance and size, although the mason bee's abdomen is more rounded, and it is covered with reddish tawny hairs. It is another species which collects pollen on the underside of its abdomen.

The red mason is an early bee, and is seen hard at work in May, making its nests in holes in walls or posts, either using existing nooks and crannies, or excavating the burrows themselves.

The female, distinguished by a pair of short 'horns' on her head, makes the cells with damp soil, using it as mortar–it is not uncommon to find the spaces within and around door locks filled with cells of earth stuck together with saliva. This is obviously the work of a mason bee. This species has two generations a year, the spring nests producing a new generation in June, the larvae of which stay in their cocoons until the following spring.

Snail shell nests The two-coloured mason bee (*Osmia bicolor*) is found only in spring in limestone and chalk districts. The female has a black head and thorax, and a red abdomen, hence its name.

This species makes its earthen cells in empty snail shells, placing the cells side by side in the larger shells, but one after another, following the spiral, in the smaller ones. When the shell is full, the female closes the mouth with an earth filling, and then cuts short lengths of grass stems and other suitable herbage, gluing them together to form a mound 4-5cm (1¾-2in) high over the snail shell so that it is well hidden. Here the shell remains, complete with the cells and larvae, until the following spring.

Wool-carder bee Another bee with the scopa on the underside of its abdomen is the wool-carder bee (*Anthidium manicatum*), commonly found in gardens. The female, which favours dead-nettles and their relatives, has a row of yellow spots along each side of her abdomen, a yellow face, and a thin covering of yellow hair. The male, however, is larger and hairier so that his spots are not as visible. He has five short spikes around the end of his abdomen, and tends to be fairly aggressive, chasing any insect of the same size as the female.

Above: A male red mason bee inducing a female to mate. This species constructs its nest (right) in holes in walls or posts, and can be a considerable nuisance to owners of old houses because the females burrow into crumbling mortar.

Below: The wool-carder bee, so-named because its nest resembles a length of wool.

The female wool-carder bee constructs her nest in holes in wood, which are either already present, or which she has excavated herself. She lines the chosen hole and makes her cells from balls of woolly down, stripped from the leaves of such plants as *Stachys lanata* and the cobweb house leek. She then covers the inner side of the cells with a transparent film–presumably dried saliva–and then places a liquid mixture of honey and pollen within. The egg is laid so that it floats on top of this liquid.

If you find such a nest in a rotten log or garden shed, you can see that it resembles a length of thick woollen cord, with swellings which show where the larvae have spun their tough brown cocoons. There is only one generation a year, and the adult bees emerge in mid-summer and can be found on the wing until September.

INTRODUCED SPECIES AND GREAT ESCAPES

The natural ebb and flow in the populations of animal species results in some decreasing to the point of extinction and others increasing to become pests. These natural changes are slow and relatively infrequent, but where man has intervened the process has been speeded up dramatically.

The British Isles have a limited number of animal species, compared with the rest of Europe. Some, such as the dormouse, must have been common in Victorian times; then it was a nursery pet, whereas now it is scarce. Others, such as the collared dove, once a rare visitor, are now established breeding species. Man has done much to influence the selection by changing or destroying habitats, or introducing new species, either intentionally or accidentally.

Introductions Some accidental introductions are of such antiquity that no details are known of the exact time when they were first made in the British Isles. The house mouse and the oriental cockroach, for example, have lived in close association with man for hundreds, if not thousands, of years and came here as involuntary passengers in ships. Other animal immigrants, originally brought here to be kept in captivity, escaped and took to life in the wild. The Soay sheep of St Kilda, and the wild goats which live in herds in several areas, belong to this category and are of great interest to students of the history of domestic animals, who see in them characteristics of ancient breeds of domestic animals. The American mink, also an escapee from domestication, is, on the other hand, a recent arrival whose success is well known.

In some cases no one is quite sure whether a particular species is introduced or truly wild,

Above: The crested porcupine (shown here) was the reported cause of forestry damage in Staffordshire in the 1970s. The related Himalayan porcupine, a native rodent of the central and eastern Himalayas, originally escaped from the Pine Valley Wildlife Park near Okehampton in Devon in 1969. Ever since then there has been great excitement when quills have been found in the undergrowth or in abandoned badger setts, and damage has been noted in conifer plantations. Porcupines appear to prefer to eat Norway spruce saplings in the British Isles, although in their native habitat they take mainly roots and farm crops.
In recent years there have been fewer reports of supposed porcupine damage, which is a relief to those who feared the species might become a pest on the scale of the coypu in East Anglia.

since its history is obscure, and the evidence is conflicting. For example, conventional wisdom says that the Exmoor pony, like all the other local British varieties of the horse, is a feral animal, a domesticated creature which has escaped from man's control and taken up a wild existence. So the Exmoor is an introduced animal. But is it? The Exmoor has many primitive features, for example an extra-thick wiry coat and strong bones, and it can survive the coldest and bleakest Exmoor winters without human help. Some zoologists are convinced that the Exmoor is a truly wild horse, with prehistoric ancestors.

Deliberate introductions These are even more numerous than accidental introductions, and a comprehensive list would take much space. Because the British Isles were cut off from Continental Europe before many species which prefer milder climates had reached the British landmass, the fauna of the British Isles is relatively impoverished.

Many steps were taken to enrich our fauna, particularly in the 19th century. The main reasons for introductions have been economic (the rabbit, for example), or for decoration (the mandarin and ruddy ducks and the edible dormouse, for example), or to provide sport (for instance, deer, pheasants and rainbow trout). Sometimes more than one of these reasons are combined–the rabbit was later introduced as a game animal as well.

Attempts at biological control are a more recent reason for introducing species: in many cases a species becomes a pest because the predator or parasite in its native habitat is absent, therefore they in turn may be brought in. There is no good British example of successful biological control, although some parallels may be seen in the way that myxomatosis, imported from South America, via France, has achieved a marked reduction in the rabbit population.

Some species (the mink, grey squirrel and rabbit) have been spectacular successes, but many introduced species fail completely to establish themselves as self-perpetuating residents. Guinea pigs often escape, yet wild colonies never survive. Ferrets were released in thousands when the arrival of myxomatosis made them temporarily redundant, but it is doubtful whether any of their colonies would survive without constant replenishment from new escapees. Some species survive in the wild on a limited scale, such as the night herons which escaped from Edinburgh Zoo and the golden hampster, a frequent escapee from pet shops.

Above: The ring-necked, or green, parakeet, a native of India, Africa, Malaysia and south-western China, has escaped from captivity many times in this country and is sometimes seen to the south and west of London. These birds are not popular with fruit growers: they take both buds and fruits.

Below: The feral red-necked wallaby, a native of Tasmania, has a tenuous breeding population in northern England.

Success or failure The study of the ecology of introductions is relatively new, and few scientific investigations have been carried out. Part of the explanation for success or failure of a species may lie in the concept of the 'vacant niche'–an environment which can support a population of a particular species. Some scientists say that there is no such thing, since a niche is only evident when occupied by the appropriate animal. Yet the idea has appeal: attempts to re-introduce the wolf or the wild boar would probably be unsuccessful, because the habitat has been so changed by man that the resources they would need to survive in the British Isles are no longer there–their niche has disappeared.

On the other hand, until recently the British Isles had no mink. As we can see now, with the benefit of hindsight, the mink niche was vacant. Today the mink thrives in our countryside, neither competing too seriously with otters in our lakes, rivers and sea-shores, nor with stoats and weasels on land, and harvesting enough of our small wildlife to support itself without causing any widespread destruction (despite some opinions to the contrary).

Sometimes, however, a colonist displaces another species. In much of the British Isles the grey squirrel appears to have displaced the native red, and in Europe, for example, the American mink has displaced the native European species. Preliminary research has shown that in these and similar cases there is no direct competition between the species, but rather that the species which contracts its range was already in retreat before the newcomer arrived. With the grey squirrel and the mink massive man-wrought alterations to the environment are the likely cause. When the newcomer arrived, better adapted to the changing conditions, the retreat was accelerated. The match between niche and new occupant was then better, so the newcomer quickly replaced the old inhabitant and became an established species.

In the case of the small colonies of animals which spread only slowly, if at all, one can only assume that the resources in the habitat are inadequate for the animal's needs, so the invader is unable to build up a large population. The situation can persist for a long time, though a subtle change in the environmental factors can extinguish the colony.

A similar argument probably explains why newly-established colonies are so precarious, taking time to reach a level where rapid expansion is possible. The small colony, even in favourable conditions, is thinly dispersed and liable to serious depletion, even extinction, as a result of quite small environmental changes. However, at a certain point–different in every case–conditions are right, and a new member of the British fauna is established. We have seen this many times in our past, and no doubt will again, by accident or design, despite the hazards.

Above: The American mink had a humble beginning here on the edge of Dartmoor in the 1950s but within 25 years it has become a runaway success in most of mainland Britain.

Right: The stick insect, a popular pet, lives wild on Tresco on the Scilly Isles. It seems to have got there accidentally, with some of the tropical and sub-tropical plants.

Below: The Mongolian gerbil, an introduced species, is a popular pet. It often escapes, yet only one self-perpetuating colony is known: on the Isle of Wight.

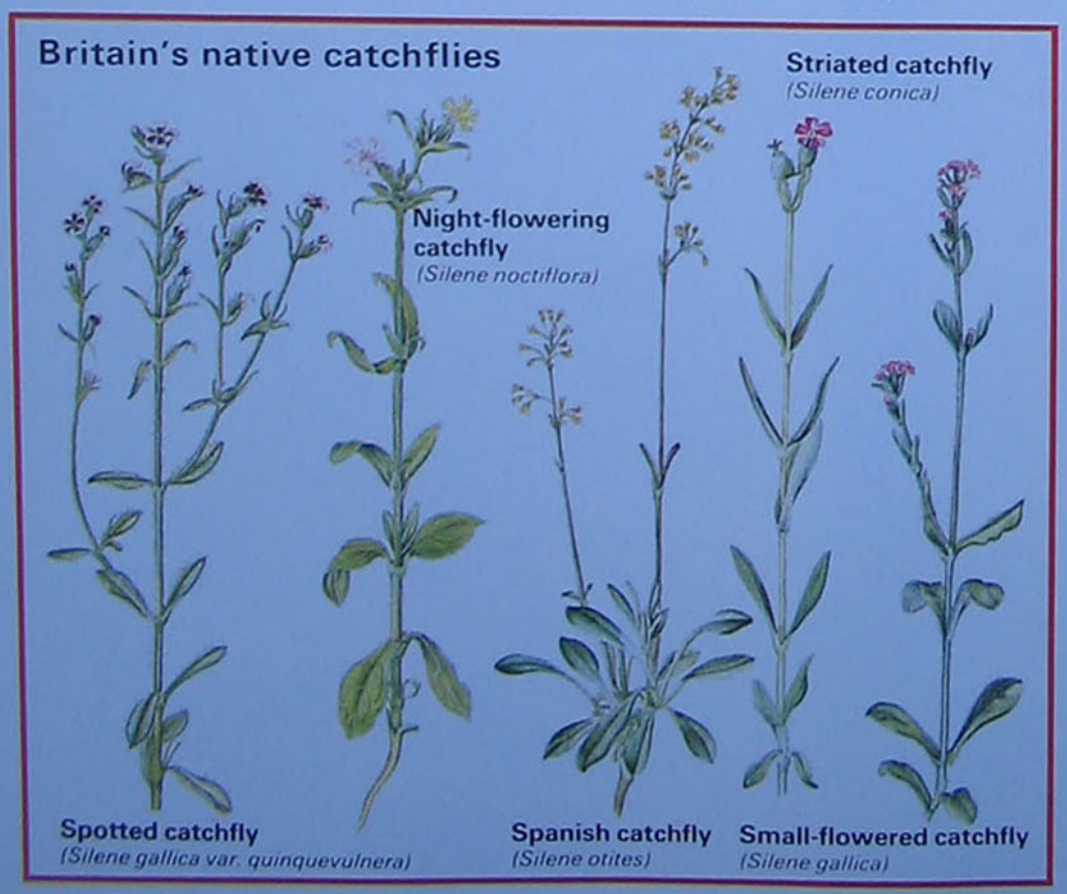
STICKY CATCHFLIES

Catchflies are so called not because they catch flies for food but because their stems have sticky hairs for trapping small insects out to steal their pollen or nectar.

Catchflies are annual or perennial herbs with white or pink flowers. They are members of the campion family (Caryophyllaceae), to which the familiar pinks and carnations belong. Like these plants, they have leaves arranged up the stem in pairs. The nodes (where the leaves join the stem) are thick and give the stem a knobbly appearance–a characteristic of many plants belonging to this family.

The name catchfly, with various distinguishing prefixes, describes many species of the genus *Silene* that have sticky, glandular hairs on the upper parts of the stem. These prevent small insects from climbing up to reach the flowers and steal the pollen or nectar. Although small flies can be caught in this way, it is often wingless worker ants that become trapped in the sticky hairs. If they were successful in crawling up the stems they could collect nectar but would be unlikely to effect pollination because of their size–generally it is the larger flying insects that pollinate the flowers.

Above: The Nottingham catchfly (*Silene nutans*) is a variable species found in open, often rocky, habitats such as cliffs and old walls, and also on sand and shingle. Its flowers open fully at dusk.



Striated catchfly Of the seven or so native species found in Britain many are rare and have restricted distributions. One such is the striated catchfly, sometimes known as the corn catchfly. It is found chiefly on the coast of eastern England and Scotland on dunes, sandy fields and waste places, but occasionally also inland, such as in the Breckland of East Anglia. The erect, stiff stems grow to between 10cm (4in) and 35cm (14in) high and are usually branched, bearing small flowers less than 5mm across from May to July. Only a few flowers are open at any one time. The pink petals are heart-shaped with two scales at their base. The calyx, which is formed from the petals, looks inflated and has a broad base tapering to a narrow neck. It bears 30 greenish ribs alternating with white furrows.

Spanish catchfly Another catchfly to be found in the heath-like Breckland is the dainty Spanish catchfly. Despite its name it is a native plant of Britain. Its flowers are tiny, only 3-4mm in diameter, and pale greenish-yellow in colour. The petals are narrow, do not have a notch at their top and lack the two small scales at their base possessed by the flowers of most other catchfly species. The narrow bell-shaped calyx has ten faint veins.

The soil in Breckland is dry, partly because of its porous nature (sand overlying chalk) and partly because the rainfall is low in this part of the country. A small group of plants–rare in Britain as a whole–has become adap-

ted to these very dry conditions. They are sometimes known as 'steppe' species because they also occur in similar habitats in central Europe. Spanish catchfly is one such steppe plant.

Small-flowered catchfly This plant is uncommon in Britain but may be widespread in a few areas. It is an annual and grows in sandy or gravelly fields and waste places. Its stems are between 15cm (6in) and 45cm (18in) high and the sticky hairs on their upper parts demonstrate how appropriate the name catchfly is by the number of small flies and other insects that they catch. The lowermost leaves are spoon-shaped but become progressively narrower higher up the stem.

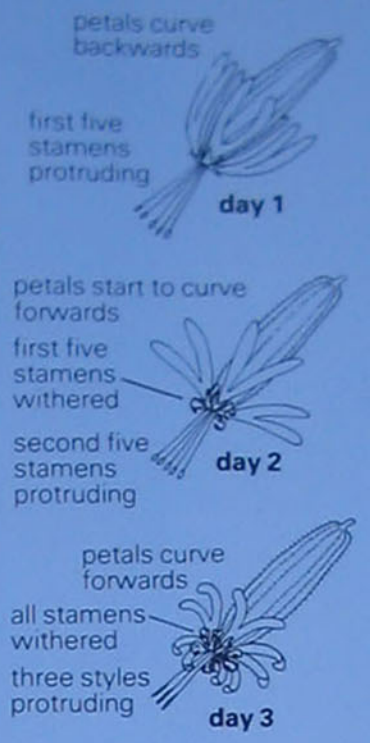
Nottingham catchfly As its name suggests, this plant was first recorded in Britain from Nottingham Castle, being described as early as 1696 by a famous British botanist, John Ray. It is a perennial and has nodding white or pinkish flowers with deeply cleft petals. If you look for Nottingham catchfly in the morning or afternoon you may think the plant has finished flowering. It is only at dusk, when the flowers begin to give off a strong fragrance, that they become fully open and attractive to the night-flying moths, their main pollinators.

After flowering is over, an egg-shaped capsule develops which, when mature, opens in the shape of six spreading teeth and releases kidney-shaped seeds. These are a few millimetres in diameter and densely covered with small tubercles.

Night-flowering catchfly Most plants pollinated by night-flying insects are specially adapted to attract them in some way – their flowers are white or pale shades of pink or yellow so that they stand out more clearly in the poor light of the evening. A strong scent is a further aid in guiding the insects to the flowers. The aptly named night-flowering catchfly has both these adaptations. During the day the petals are rolled up, showing only their dull greenish-yellow undersides. It is only during the evening, usually between five and eight o'clock, that they uncurl to reveal their pale rosy surfaces to the night. As the petals spread, the flowers become fragrant and remain so until the following morning. The plant can usually be seen in flower between July and September, although its flowers are inconspicuous during the day.

Night-flowering catchfly has decreased in numbers, probably because much-improved agricultural screening techniques remove undesired seeds from crops before sowing. Another factor could be wet weather. Research has shown that a high percentage of seeds germinate successfully only in a sunny year. Because night-flowering catchfly is an annual, local populations may suffer badly as a result of a wet season.

The three-night cycle of the Nottingham catchfly



The Nottingham catchfly has an unusual flowering pattern that spans three successive nights.

Day 1 Towards sunset the flower opens, the petals being recurved back with five stamens pointing forwards ready to shed their pollen.

Day 2 During the following day the petals start to curve forwards and the first group of stamens curve back and wither, to be replaced during the evening by a second group of five stamens with anthers full of ripe pollen. If, during the first two evenings, insects visit the flower they leave with pollen on their backs. Self-pollination is prevented because all this time the styles remain unreceptive and hidden in the depths of the flower.

Day 3 In its final stage the flower has all its stamens curved back and withered, and three styles become elongated and protrude through the petals, which are now pointing forwards. The styles are now receptive to pollen deposited on them.

Below right: The small-flowered catchfly can have pale pink petals as well as white. A variety found in the Channel Islands has flowers with a deep crimson blotch at the base of each petal.

Below: The alpine catchfly (*Lychnis alpina*), belongs to the genus *Lychnis*, unlike the other catchflies mentioned here. The stems grow to between 5cm (2in) and 15cm (6in) high and, despite the plant's name, do not have sticky hairs for catching flies. This species is perennial and flowers from June to July. Alpine catchflies are very rare, only being found on the mountains of Cumbria and eastern Scotland.

EMERALD, WAVE AND THORN MOTHS

The geometers, a vast family of moths comprising some 270 species in Britain alone, are divided into groups under such evocative names as the emeralds, the waves and the thorns. So numerous are they that even the smallest city garden is likely to support a few species belonging to these groups.

Above: The early thorn (*Selenia dentaria*), in common with most other thorn moths, holds its wings up over its back in much the same way as a butterfly—an unusual stance for a moth.

Below: The swallow-tailed moth (*Ourapteryx sambucaria*) is commonly seen flying around in the suburbs, just as the sun is setting.

Geometers are generally thin-bodied moths with relatively large wing surfaces. Almost all species fly by night, and the males in particular are attracted to bright electric lights. By day both males and females rest on tree-trunks, walls and fences, their well-camouflaged wings matching the backgrounds on which they habitually rest. Occasionally you may see a geometer which has been disturbed from the vegetation on the wing in daylight. It will take only a short flight, however, before coming to rest in an identical position on another plant.

Measuring worm The name geometer refers to the caterpillars' mode of locomotion. To move forward a geometer caterpillar stretches

out as if to measure the distance, and then secures a hold with its front legs. Next the entire length of its body is formed into an arch, and the rear end is brought forward to the point of attachment of the front legs.

Virtually all geometer caterpillars rest motionless by day, usually attached by their rear claspers to a twig or leaf. At night, when they are safe from predators, especially small birds, they feed and move around on the plant leaves. Most geometer caterpillars are impressively camouflaged, a large number of them resembling twigs, which has earned them the name 'stick caterpillars'.

Sparkling emeralds One of the most distinctive groups of geometers is that of the emeralds, a name referring to the moths' wing colouring–all nine British species have bright emerald-green wings.

The large emerald, which has vivid green wings when it first emerges, although the colour soon fades to a rather weak yellowish green, flies at night in June and July, in woods and on heathland. The female large emerald lays her whitish eggs on birch leaves, where they hatch into short stumpy brownish-green caterpillars. These feed for a time before spinning a silken pad on a twig. Here they will pass the winter. As soon as the birch buds burst in spring they start feeding again and are fully grown (and entirely green) by the end of May. The green pupa forms inside a silken cocoon at the base of the tree, and is usually well hidden among dead leaves.

The smaller common emerald, distinguished by its pointed green wings, edged with red dots, is more likely than any other species to turn up in town gardens. It occurs frequently in the south, and flies at night in June and July. The female lays her eggs on mugwort, where the young caterpillars feed, although after hibernation they move on to trees and shrubs such as birch and hawthorn.

A much rarer species is the Essex emerald, a moth which has always been confined to the Essex saltmarshes, but is now feared to occur in only one locality. Consequently it is now considered an endangered species, and is protected by the 1981 Wildlife and Countryside Act. Killing or molesting this species can result in a fine of up to £1000. The caterpillars feed on sea wormwood, and have the curious habit of decorating themselves with pieces of the foodplant, presumably as a means of concealing themselves from predators.

Above: The scallop shell (*Rheumaptera undulata*) is on the wing in June and July in woods and marshy habitats, where the caterpillars feed on sallow and bilberry.

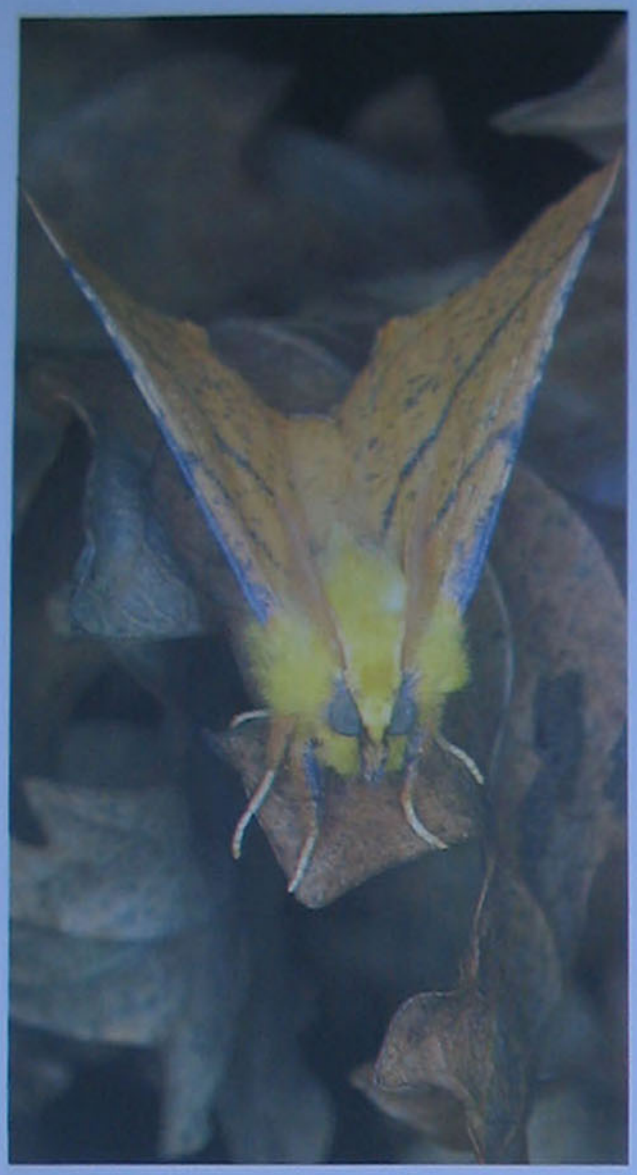
Right: The common emerald moth (*Hemithea aestivaria*) occurs in town gardens and is easily recognised by its pointed, angular green wings.

Below: As its name implies, the large emerald (*Geometra papilionaria*) is the largest of our emeralds. It is a magnificent moth when newly emerged, but unfortunately the colour soon fades to a weak yellowish green.

Thorns Rather stouter in body and more robust-looking than the emeralds, the thorns form another distinctive group of geometer moths. All thorn caterpillars are remarkably twig-like, occurring on most deciduous trees and shrubs–if you find a stick caterpillar on a garden shrub, it is most likely to be one of the thorns.

The first species to appear in spring is the early thorn, a moth which flies on warm nights in March and April. Next to appear, in April, is the scalloped hazel, a rather sombre-looking brown moth, common in towns, where the caterpillars eat the leaves of ornamental shrubs such as privet and buddleia.

By summer several species of thorns may be flying around the garden: among them the scalloped oak, the canary-shouldered thorn,



Industrial melanism in peppered moths

The typical form of peppered moth (*Biston betularia*) is white speckled with black, but in the 19th century an all-black form appeared in industrial areas, and spread so that it now comprises 90% of the urban population. This phenomenon – known as industrial melanism – is a perfect example of evolution by natural selection. The typical white form gains camouflage from its resemblance to lichen, but as lichen disappeared from areas suffering from industrial pollution, the new black form evolved to match the dark bark of trees.

Left: The canary-shouldered thorn (*Ennomos alniaria*) is a common species which flies at night and rests on tree-trunks during the day. The adults occur in woods in early autumn, so their yellow wings, which resemble withered leaves, give them perfect camouflage.

the dusky thorn and the swallow-tailed thorn (a large creamy-white moth often seen at dusk in the suburbs). Another species common in towns in summer is the yellow-coloured brimstone, the caterpillars of which feed on hawthorn, plum and cherry tree leaves. Although most brimstone caterpillars are green or brown, and twig-like, those found on the purplish leaves of certain ornamental cherry trees are purple in colour. This suggests a relatively recent evolutionary adjustment, as purple-leaved cherry trees have only been grown in this country for a few hundred years.

The large thorn is an early autumn species, and was first recorded in Britain in 1855, although it has now spread to many localities in the south, particularly along the coast. Another species, the feathered thorn, flies still later in the year, in November, and the males come to the lights in houses on mild foggy nights. In common with certain other species of thorns, the caterpillars are successfully exploiting the wide range of alien ornamental plants now grown in gardens. This should mean they thrive, unlike the Essex emerald which, because of its specialised requirements, is virtually doomed to extinction.

Below: The blood vein (*Timandra griseata*) belongs to the group of geometers known as the waves. This species rests among leaves, and is not difficult to identify, with its pink stripe running diagonally across its wings.

Dainty waves Another group of geometers, the waves, consists of many similar looking species that are difficult to identify. There are, however, a few conspicuous species, often found close at hand in the garden. One of these, the blood vein, is a pretty moth with a deep pinkish stripe running diagonally across its wings. The brownish caterpillars feed on low plants (weeds and garden ornamentals that are mainly annuals).

Another species whose caterpillars feed on low plants is the riband wave, a variable but generally rather dull-looking moth which can be extremely abundant in town gardens. In some years vast numbers of riband waves can be attracted to bright lights, while in other years they may be less common. Despite these fluctuations in population, the moth is a resident species.

The vestal, unlike the riband wave, is a migrant since it cannot survive our winters at any stage of its life-cycle. This pale, silky-winged moth, with a reddish or brown stripe across its forewings, is resident in southern

Europe and North Africa, and was not recorded in Britain until 1857. Since then it has been reported in many parts of the country, usually as a rare migrant, although there is evidence to suggest that it is becoming more frequent. It appears that the individuals either fly deliberately, or are blown north, and on arriving here in summer, breed and produce an autumn generation. In 1947–in an extremely fine summer and autumn–the vestal was common in stubble fields in many parts of southern England, but it apparently did not survive the winter. Several years ago a number of vestals appeared in early March, almost certainly carried here by a powerful airstream from North Africa, which at the same time deposited Saharan dust.

A few species of waves are silver or creamy-white with rather indistinct and delicate markings on their wings, making them particularly conspicuous when resting on vegetation. Entomologists have always been puzzled by the way these species manage to escape detection by predators; one explanation is that they keep still so as not to attract attention, while another is that they do not appear particularly moth-like–indeed some species resemble bird-droppings.

Magpie moth Another conspicuous geometer, the magpie moth is, as its name implies, white with bold, black spots and yellow markings on the forewings. This species is commonly seen in gardens in July and August, where its equally conspicuous caterpillars feed on gooseberry and currant bushes.

The scallop shell, one of the most intricately marked of all our moths, has pale brownish-grey wings covered with numerous dark wavy lines. The male has tufts of dark hair, positioned in a special fold in the hindwing, forming a scent organ used to attract females. The short reddish caterpillars feed on bilberry and sallow, so the moth is common in woods and marshy areas, where these plants abound.

Essex emerald (*Thetidia smaragdaria*). Occurs on Essex saltmarshes. Larval foodplant: sea wormwood.

Magpie moth (*Abraxas grossulariata*). Common in gardens. Larval foodplant: hawthorn and fruit bushes.

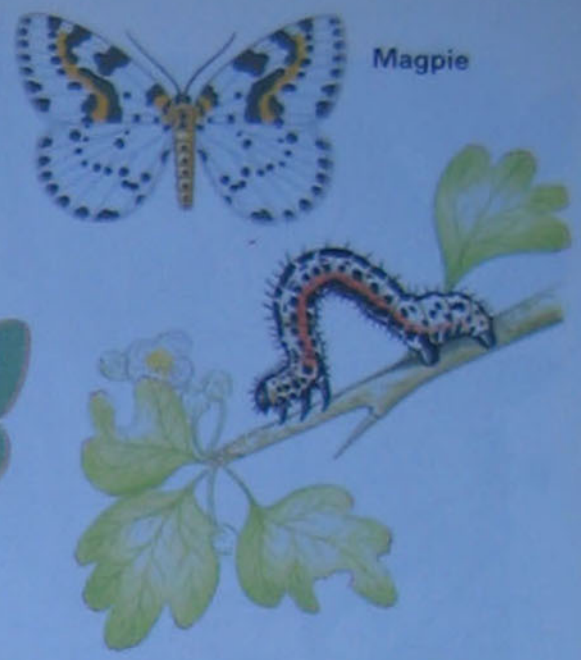
Brimstone (*Opisthograptis luteolata*). Common in urban areas. Larval foodplant: hawthorn.

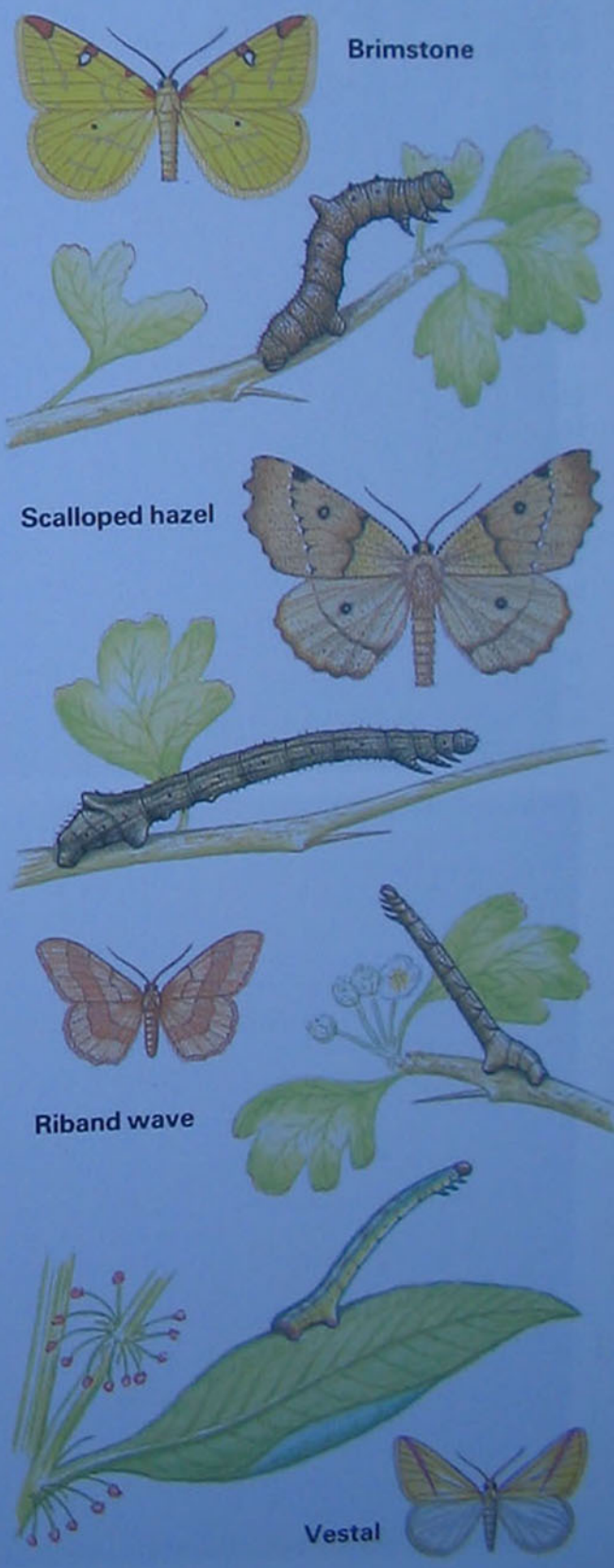
Scalloped hazel (*Odontopera bidentata*). Common in towns. Larval foodplant: ornamental shrubs and hawthorn.

Riband wave (*Idaea aversata*). Town gardens. Larval foodplant: hawthorn.

Vestal (*Rhodometra sacraria*). Rare migrant. Larval foodplant: dock.

Below: The feathered thorn (*Colotois pennaria*).





BITTER-SWEET BOG MYRTLE

One unobtrusive shrub growing in bogs, fens and streamsides has a remarkable property – it can change sex from one year to the next. The plant is bog myrtle, one of our most powerfully aromatic shrubs with a sweet fragrance yet a bitter taste.

Above: A stand of bog myrtle flowering in early May before the leaves have unfurled. Irish legend has it that bog myrtle was once a tall tree until its wood was used to build the Cross. But then, out of shame and remorse, it shrank to its present lowly stature.

Bog myrtle (*Myrica gale*). Native deciduous shrub found in damp habitats in most parts of Britain; particularly common in the north and west.

Bayberry (*Myrica carolinensis*). Deciduous shrub native to the eastern United States. Established in the New Forest, Hampshire.

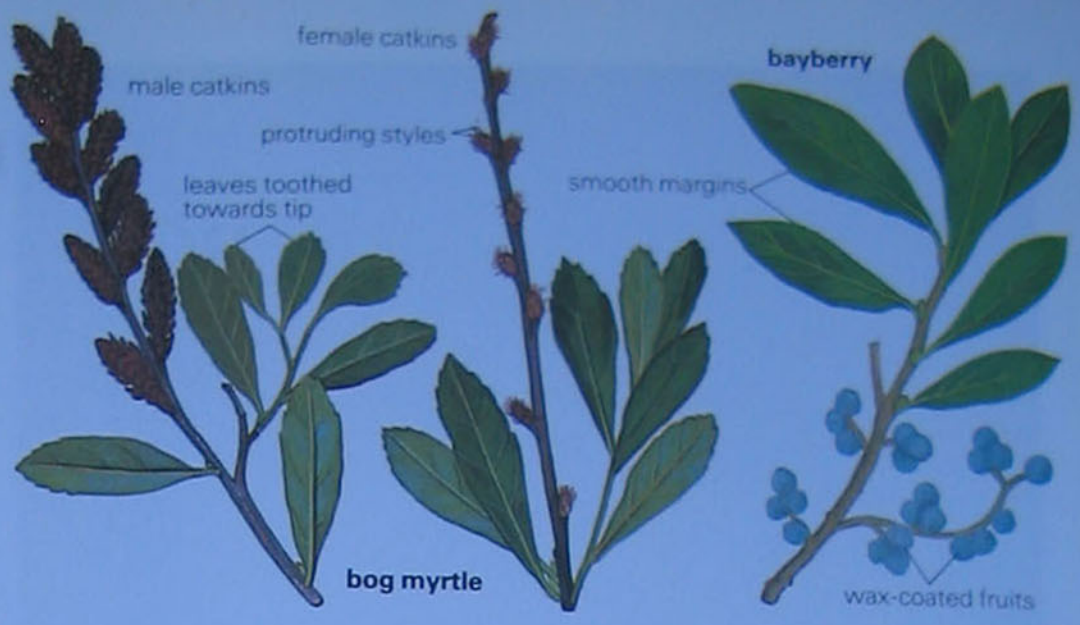
Bog myrtle, or sweet gale as it is often called, is the only British representative of the family Myricaceae. All members of this family of small trees and shrubs have leaves covered with small resinous glands that give off an aromatic scent. The flowers are normally borne in the form of catkins, a feature that causes many botanists to place this family near to the birch family, Betulaceae, though its exact position in the classification system is still not settled.

Bog myrtle is a plant of moist places, such as bogs, fens and the margins of streams. It occurs in most parts of the British Isles and in some areas, especially parts of Scotland, Ireland, Wales and western England, it can be the dominant vegetation. Conversely, however, it is unaccountably absent from some areas where it might be expected to grow, notably in parts of the Midlands and in the eastern half of the border between England and Scotland. Bog myrtle can be found at considerable altitudes; in the eastern Highlands of Scotland, for example, it grows up to about 550m (1800ft) above sea level.

Suckering shrub Bog myrtle is a small deciduous shrub usually growing to a height of 1.2m (4ft), though occasionally becoming taller. It often spreads by sending out suckering shoots, by this means sometimes forming large stands of pure bog myrtle.

The leaves are lance-shaped and are at their widest near the tip rather than in the middle or near the stalk end. (This shape is known as oblanceolate.) The margins have a few forward-pointing teeth at intervals. The upper surfaces are greyish-green and hairless, while the lower surfaces are a fresher-looking green and pubescent (hairy). The leaves, stems (which are usually purplish-brown) and all other parts of the plant are scattered with aromatic glands, which are yellow when young but become darker with age. These glands exude a sweet fragrance somewhat reminiscent of eucalyptus, but without the overtone of menthol.

Sex change The most remarkable feature of bog myrtle is the way in which some plants



Left: The fruits of bog myrtle are borne in catkin-like structures. Each fruit is a nutlet 2-3mm long and bearing two wings. Like the rest of the plant it is covered with tiny yellow glands. The leaves are 2-6cm (1-2½in) long with a few scattered teeth towards the tip.

change sex from one year to the next. All bog myrtle plants bear either male or female flowers, as do many other plant species. But, among the British flora, only bog myrtle exhibits this curious phenomenon of changing sex. As well as male plants becoming female and *vice versa*, single-sex plants may suddenly bear flowers of both sexes one year, or they may even bear inflorescences containing male and female flowers.

Almost invariably, however, individual male and female flowers are borne on separate inflorescences usually known as catkins, though the term is not strictly accurate. The male catkins are borne on last year's shoots, usually before the new season's leaves appear in April and May. Each catkin is 7-15cm (3-6in) long and consists of a number of reddish-brown scales bearing several yellow anthers tinged with red. The female catkins have a similar structure, the same reddish-brown scales containing a pair of long crimson styles that protrude well beyond the scale and are noticeable at a distance.

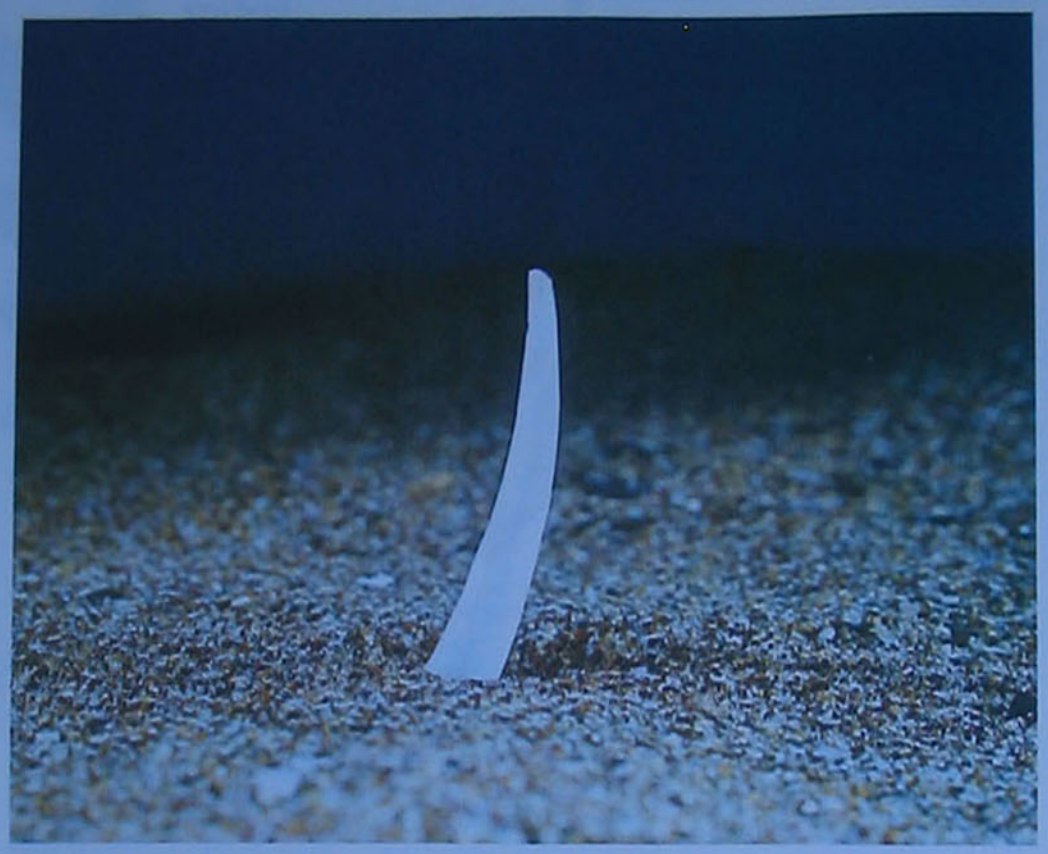
Pollination is by the wind. The fruits mature through the summer, forming a flattened hard berry or nutlet with two wings. Like the rest of the plant, the fruits are covered with glands, and they also have a greyish-white waxy coating. Despite the presence of the wings, the fruits are far too heavy to be carried on the wind any distance. Instead, they simply fall to the ground beneath the plant. There is no evidence that animals or birds feed on them and thereby distribute the seeds.

Country customs Bog myrtle is no longer an important plant commercially, but it was once used for a variety of purposes. The fragrance of the plant, whether fresh or dried, made it ideal for protecting and preserving clothing, keeping them free of vermin and imparting to them a fresh, wholesome air.

By far the most important use for bog myrtle, however, was in the production of beverages, including ale. The preservative properties of bog myrtle, combined with its bitter taste, made it an extremely useful ingredient in ale, and it created a very intoxicating drink. Both berries and leaves were used for this purpose. The use of bog myrtle in brewing declined during the 14th century, but it is recorded that it was used for this purpose well into the 18th century in the Western Isles of Scotland.

American relative A species closely related to bog myrtle has become established in at least one place in the New Forest, despite being native to the eastern United States. This plant is bayberry. It grows in slightly drier soils than bog myrtle and appears to spread only by suckers, for its seeds are not viable here. Bayberry is similar in appearance to bog myrtle, the only differences being that it is somewhat taller, the catkins appear at the same time as the leaves and the fruits are covered in a thicker layer of wax.

Below: Male flowers of bog myrtle. Despite the sweetish fragrance of this plant, which accounts for one of its many common names—sweet gale—all parts have a bitter taste, none more so than the male catkins.



UNUSUAL SEA-BED MOLLUSCS

Above: The tusk shell *Dentalium entalis,* showing the oblique angle at which the shell protrudes from the sand surface. The animal lives and feeds in sand at the bottom of the sea. Often only the tip of the shell emerges from the sand.

The sea-bed is the home of some very unfamiliar molluscs. Among these are the tusk shells and a group of worm-like animals known as the aplacophorans.

Tusk shells are rarely found alive–except by divers–but their empty shells are often cast up on sandy beaches. The white shells are well named, for they are usually curved and always tapering–like the tusk of an elephant. The shell is open at both ends, and in life the tip of the thinner end projects obliquely up into the water from the sand in which the tusk shell is buried. There are about 350 species of tusk shell worldwide, but only one is widespread in British waters–*Dentalium entalis*. This tusk shell reaches 3.5cm (1½in) in length, and usually lives half buried in fine sand at depths of 30-60m (15-30 fathoms) in the sea.

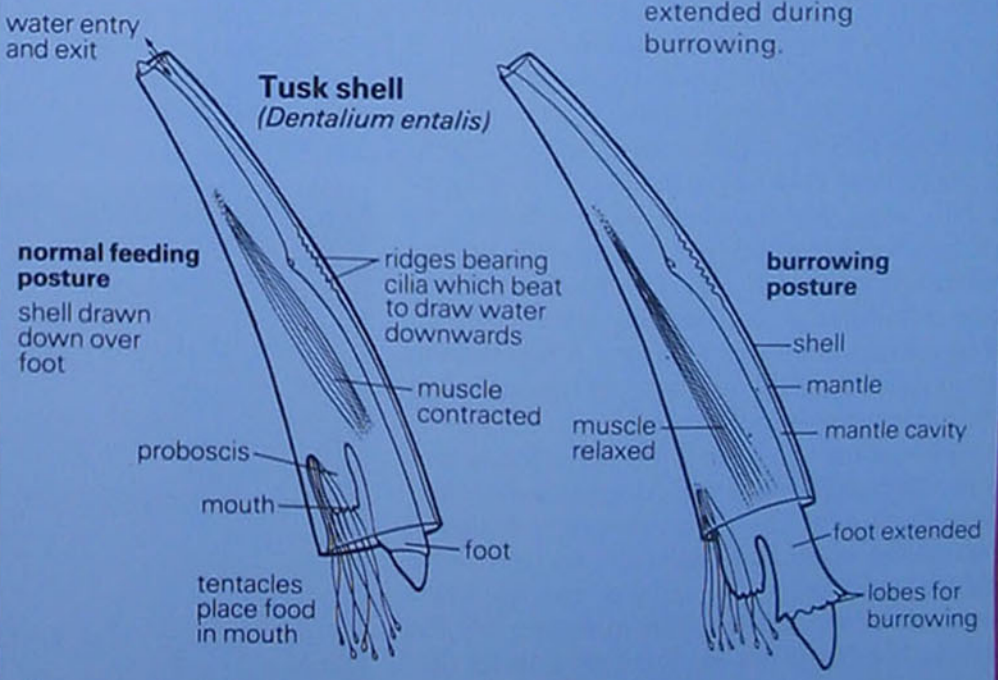
The structure of the tusk shell is highly specialised, being precisely adapted to the sandy sea-bed habitat. Tusk shells first evolved during the Devonian period, 400 million years ago, when specimens recognisable as tusk shells perished after being buried in the sand. Some of these buried animals became fossils, providing us with a permanent record of the evolution of tusk shells.

Feeding and breathing The shell is a tube enclosing the body and the mantle cavity; at the bottom end the foot and the head, with several bunches of tentacles, protrude into the sand. The tusk shell uses the tentacles to feed. They are extended on either side of the head and search for pieces of organic detritus or for small single-celled organisms called foraminiferans. Each tentacle is covered in little hair-like structures (cilia), and food particles are first engulfed in mucus and then passed by the cilia along the tentacle to the mouth. The lobes of the foot may also assist in the capture of slightly larger food particles. Up to 100 foraminiferans have been found at one time crammed into a tusk shell's proboscis–the feature that supports the mouth. Inside the proboscis is the radula–a ribbon-like structure bearing rows of teeth. These teeth seize each foraminiferan in turn and pass it into the stomach, where it is crushed to a pulp and digested.

Tusk shells breathe by extracting oxygen from the sea water that passes in and out of the top end of the shell. There are no gills, but the walls of the mantle cavity are richly supplied with blood and act as respiratory surfaces. Every ten minutes or so there is a sudden expulsion of water from the mantle cavity, followed by an inrushing of more water. Water then enters more slowly until the next expulsion and sudden entry. The major water movements are caused by muscular movements of the foot, and the slower entry of water is produced by the beating action of cilia

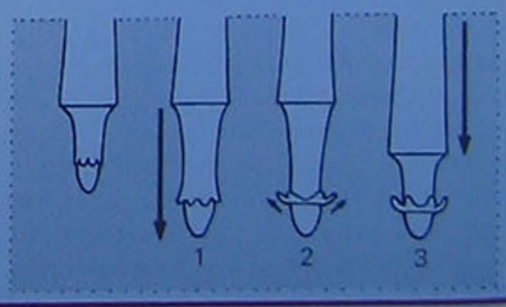
Anatomy of a tusk shell

The shell is lowered over the body during normal feeding; the foot is extended during burrowing.



Burrowing action

The tusk shell burrows at an angle, using the lobes of its foot. The pointed foot is forced down into the sand with the lobes pressed flat (**1**). The lobes are extended like an anchor (**2**), and the shell is pulled down into the sand by the contraction of muscles (**3**).



lining the mantle cavity.

Tusk shell reproduction Males and females are separate, and fertilisation of the egg occurs externally in the sea. The fertilised egg divides to form a trochophore larva similar to that of chitons, limpets and primitive bivalves, and even of some bristle worms. This larva swims in the sea and in turn develops into a later stage similar to the more highly developed veliger larva of most bivalves, before settling on the bottom. The shell at this stage consists of two parts, as in bivalves, a feature which may indicate an evolutionary link between the tusk shells and the bivalves. The two halves of the shell of the developing tusk shell then fuse to form a tube, and the body elongates to take on the adult form.

Introducing aplacophorans The other group of unusual molluscs living at the bottom of the sea contains about 250 species, about which comparatively little is known. These are the aplacophorans, which are unlikely looking molluscs–they have no shell and, being elongated with poorly developed heads, look much more like worms. In place of the shell, minute calcareous spikes (spicules) are present and these sometimes protrude, like a silvery fur. These molluscs not only lack a shell; they also lack the typical molluscan foot. Like other molluscs, however, aplacophorans do have a mantle cavity, which consists of a small space at the back of the animal.

Burrowing species The aplacophorans are made up of two groups of animals occupying very different ecological habitats. One group, containing only two genera and typified by *Chaetoderma nitidulum*, lives in a wormlike fashion as befits its shape, burrowing in sediments at the sea bottom.

Aplacophorans are usually said to be ecologically unimportant, but it has only recently been realised that *Chaetoderma nitidulum* may well be quite common and ecologically significant in some marine sediments, even in relatively shallow waters such as those of Milford Haven in south-west Wales. *Chaetoderma* is predominantly a detritus feeder, living on organic matter and on single-celled organisms such as foraminiferans just as many burrowing worms do. These burrowing aplacophorans have two large plume-like gills in the posterior mantle cavity, one on each side of the anus.

Sharp-toothed predators The other group of aplacophorans is much larger, containing 24 genera, of which three are found in British waters. These aplacophorans, of which *Neomenia* and *Proneomenia* are examples, are predators of bottom-living coelenterates such as hydroids. Hydroids are superficially plant-like colonial animals living on the sea bottom.

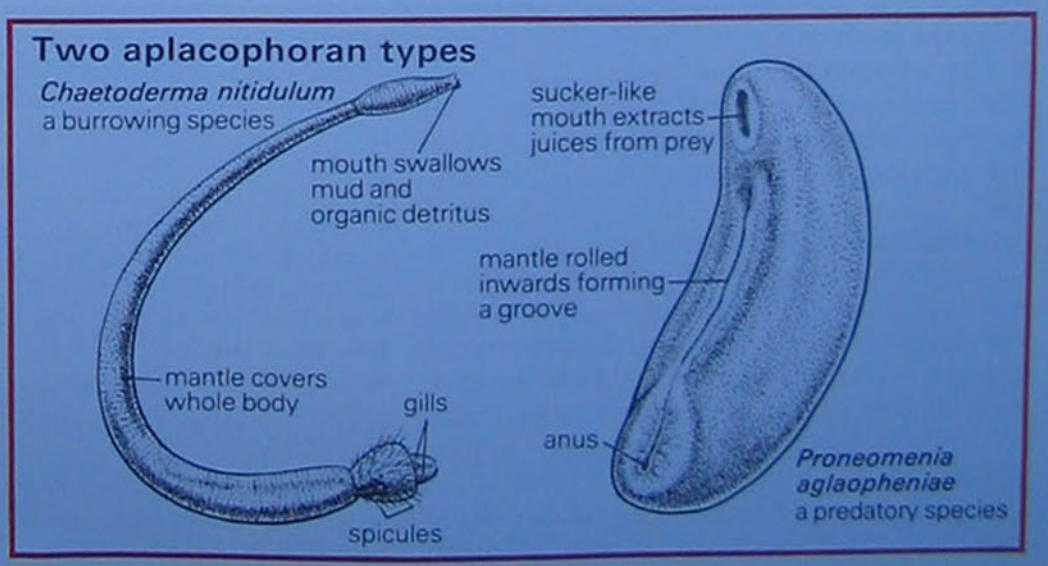
The predatory aplacophorans remain in position on their prey for most of their lives. They feed by sucking out the juices of the prey; to extract these, they make an incision with the radula, which consists of several sharp teeth. *Neomenia* and its relatives lack the feather-shaped gills which are typical of many molluscs, and instead have a circlet of small skin folds which are well supplied with blood and act as respiratory surfaces.

While all aplacophorans lack a foot, in the predatory species the need for a means of locomotion is met by a groove along the body. This is formed by the inrolling of tissue on each side of the groove, and is used as a sucker to grip on to the substrate.

Highly modified molluscs The tusk shells and aplacophorans are both successful groups in their respective ways of life. Although they are unfamiliar to the general public, and indeed to many naturalists, they are interesting for what they show us about the process of evolution. The typical molluscan body structure–consisting of a head, a foot and a body, covered by a shell–has changed considerably in the evolution of the tusk shells, and even more so in the case of the aplacophorans. Together, these animals show a range of advanced adaptations to three extremely widespread habitats of the sea-bed–sand, mud and rocks encrusted by colonial animals.

Above: This worm-shaped animal is a specimen of the aplacophoran *Nematomenia banyulensis*. It was found in the Forties oilfield in the North Sea, feeding on the hydroid which you can also see in the picture. Although its worm-like shape might suggest it is a burrowing animal, it belongs to the non-burrowing predatory group, together with *Neomenia* and *Proneomenia*.

Below: The illustration shows typical examples of the two different forms of aplacophoran. In the burrowing species the mantle covers the body completely, while in the predatory species a groove along the body is the equivalent of the usual molluscan foot.



THE WILDLIFE OF BARNS AND SHEDS

Outhouses offer animals a place to shelter from heat, cold or glaring light and provide nooks and crannies for roosting, nesting and hibernating sites, while the web of invertebrate life they support presents predators with an excellent food supply.

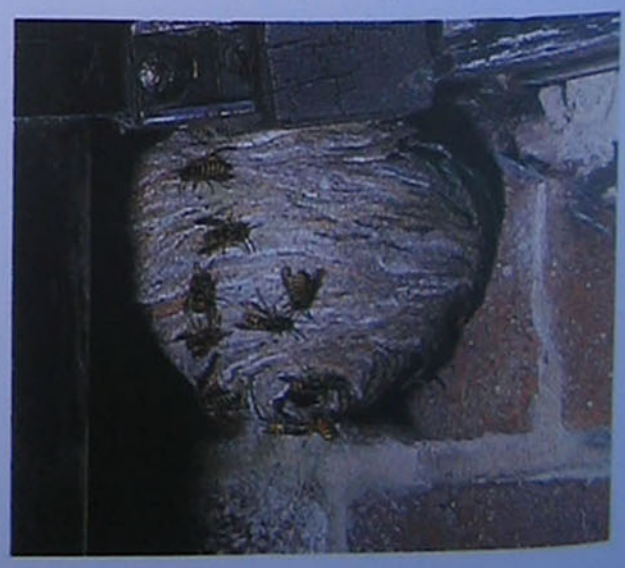
From the point of view of the abundance and variety of their inmates, sheds, barns and other outhouses are rather like our gardens – the older, better-established and often more unkempt they are, the more wildlife they contain.

Indoor insects A garden shed filled with stacks of old cardboard boxes and newspapers is a haven for the primitive wingless insects known as silverfish. They thrive between the damp mouldering layers and, with the capacity to digest cellulose, can subsist on a diet of starchy tissue (including plant bulbs), paper and glue, supplemented by the debris that collects between cracks in the floor. Since silverfish are active mainly at night, they are not often seen.

The other chief inhabitants of this microhabitat are the diminutive booklice, which likewise relish the paste in bookbindings, and also graze on the fungus mould that develops between layers of damp paper. If the soft wood cladding of a shed becomes very sodden it is vulnerable to a much more insidious fungus – dry rot. The reddish-brown spores germinate in wood with about 20% moisture content. Thus nourished, the fungus can spread to drier areas of the walls and, in time, cause collapse of the whole structure.

Among flying insects, wasps and bees commonly choose outhouses as breeding sites. A typical sign of spring is a queen wasp (either

Above: It is small wonder that so many species of animals shelter in farm barns and outbuildings like these in winter, but the spring/summer population can also be high – the buildings offer nest sites for birds and insects, while mammals may burrow into hay bales and feed on stored grain and fodder.



Right: By the end of summer a wasp nest in an outhouse can be 60cm (2ft) deep and may have launched upwards of 20,000 wasps.

the common or the German species), which has probably overwintered in the building, rasping laboriously with her mouthparts at the dried clapboards and making a fine wood-pulp with her saliva. Each tiny load is carried to the chosen site (perhaps a roof-beam), to be fashioned into a nest, a delicate umbrella of greyish paper only an inch or so across. It shields a few cells, in each of which the queen wasp lays an egg. The hatching grubs develop, after about five weeks, into a small squad of worker wasps which enlarge the nest.

Much less obtrusive is the mason bee *Osmia rufa*, whose breeding output is negligible by comparison with that of the wasps. On a warm spring day the female may be seen inspecting the walls of buildings for a suitable nest site. In a heavily pitted surface, such as limestone, she seems endlessly exacting in her quest, entering and reversing out of hole after hole until she finds one that is to her liking. Finally, she may decide on a crack between boards, or even a keyhole. Here she lays a small batch of eggs, leaves enough pollen and nectar for them to reach adulthood, and then abandons them.

Wasps and bees, equipped with stings, are well protected from the various centipede, beetle and spider predators that lurk in the gloomy corners of such buildings. Typical indoor spiders are web-builders, trapping the more defenceless resident prey and those, especially flies, that enter from outside. An old shed or barn is often festooned with the dusty, sheet-like webs of *Tegenaria domestica*, an agile, long-legged spider whose body grows to alarming proportions in the late summer and autumn when there is a surfeit of flies. On the window frames you often find the finer lacework webs of *Ciniflo fenestralis*, a spider more dependent on crawling insects for food.

Barnyard birds In barns, cowsheds and stables, especially where manure is allowed to accumulate, flying insects are especially abundant. These are prey to swallows hawking in the air, and to house sparrows and pied wagtails scouring the ground litter. Such insect food is particularly beneficial to the birds in the breeding season, when the enormous workload of sustaining a hungry brood puts a premium on a rich food supply close at hand. A sparrow with a midden right on its doorstep is, therefore, at a great advantage over one that has to fly further. Much of the sparrow nestlings' diet consists of dipteran flies, supplemented by caterpillars, dry grain and, where available, bread. By preference, therefore, sparrows nest in the barn abutting the food source, often tunnelling under the eaves, into the ivy-covered walls or among the thatch roofing if it is the worse for wear.

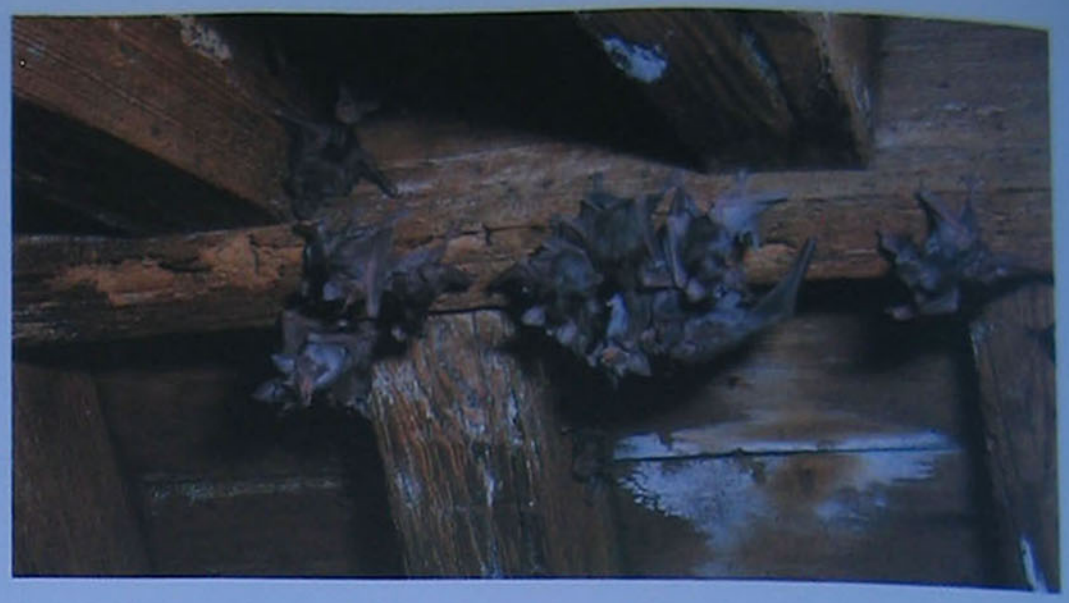
Some birds, such as the barn owl, have suffered from the loss of nesting sites as the old stone barns have been replaced with modern metal structures, but others have adapted better to the changing architecture of farm buildings. The swallow of today, for instance, can weld its nest of mud and saliva as readily to an iron girder as its predecessors did to an old oak beam.

Above: Barn owl bringing prey to its young. In times gone by, when the countryside abounded with old stone barns, the wealth of small mammal prey supported a healthy population of barn owls, which found ideal nest sites in the crumbling walls under the eaves. In the wake of modern agriculture, however, such barns have increasingly given way to more clinical metal structures, quite lacking in safe nooks and crannies. This has probably contributed to a widespread decrease in the species.

Barns also serve many birds well as safe, warm roosting sites. In farmyards the crossbeams of some outhouses are sought at dusk by collared doves which, like the house sparrows, prosper in close association with man. They are familiar on farms right up to the north of Scotland, capitalising on the popularity of cereal crops which assure them a supply of grain.

Mammal colonies Grain stores in barns attract not only sparrows but also a wide variety of small mammals, although some of these, too, supplement their diet with insects. A garden shed is often home to the relatively innocuous wood mouse, especially in winter when it offers welcome refuge and warmth. From here nocturnal forays are made into the garden to feed. Another incomer is the harvest mouse, which likewise resorts to the comfort of barns for the winter, sometimes in large numbers. (Up to 30 harvest mouse nests

Below: Web-spinning house spiders quickly inhabit the dark neglected corners of outhouses, trapping flies and other insects that come too near their webs.



Above: Young horseshoe bats in a communal roost among the rafters of an outhouse. As with the barn owl, the disappearance of the traditional farm barn has greatly reduced the number of suitable hibernating sites available to bats.

Left: Some birds are great opportunists: this wren has built its nest in an old cap hung in a garden shed. Here it is relatively secure from the attentions of cats and other predators.

were once found in a single stack of hay bales on one farm in Lincolnshire.) Much less welcome, however, is a colony of brown rats, which devour and soil the stores of grain and fodder.

Among the larger mammals, the fox–if given the opportunity–is a frequent visitor to farmyard barns. In the spring foxes sometimes choose the barn foundations in which to excavate their den. In recent years, with its spread into urban habitats, the fox has also taken to making its earth beneath the floors of garden sheds, where it may find less opposition than it does from the farmer. Feral cats, if unmolested, may also establish their colonies in barns, and a score or more cats may operate from there, radiating out to hunt voles and mice, small birds, and even insects in the surrounding countryside.

Winter refuges In winter farm buildings have special survival value to very small birds, which quickly lose body heat in the long cold nights unless they can find a snug roost. Many wrens improve their lot by roosting cheek by jowl in holes in walls, thatch, and even in swallow nests. The wrens, normally pugnacious as individuals in defence of territorial claims, are united in the common goal of shared body warmth, clustering peaceably in a tight ball.

The insulation of their fellows also accounts, in part, for the communal hibernation of some of our smaller bats, notably the pipistrelle and the whiskered. Hundreds may assemble to hang in the lofts of old barns, often representing the combined population of the surrounding countryside. The spectacular long-eared bat, however, shuns the company of others, hibernating alone in stables and cellars.

Various other animals are likewise attracted to the shelter of outbuildings for winter hibernation. Many insects, such as ladybirds and earwigs, overwinter between slats of wood, under eaves and in similar retreats. Most go unnoticed, but a warm winter's day may coax an unexpected butterfly into activity. Common hibernators are the tortoiseshell and the peacock. Many are conspicuously faded and tatty and only a few are vigorous enough to breed in spring.

Toads and newts also creep into the lumber of a garden shed to overwinter, mostly entering and leaving unseen. Toads sometimes favour a crevice under the paving in a greenhouse, where the higher temperatures help them to eke out their winter fat stores. Among reptiles, slow-worms often hibernate indoors.

The barn population

There can be few places in the countryside which offer wildlife more in the way of food, shelter and security than an old farm barn–provided, of course, that the farmer does not adopt stern measures to eradicate the wild creatures that take up residence there.
In the dark upper reaches of the rafters you may find a nursery colony of pipistrelle bats, the young huddled together to conserve warmth and moisture; barn owls, too, may roost and rear their chicks in a dark corner high up under the eaves, while collared doves settle for the night on the barn's cross-beams. Swallows, many of them returning to the same place year after year, site their mud nests where two beams meet; they, and the house sparrows that nest under the eaves or among the ivy climbing the barn wall, find plenty of insect food about the barnyard, especially where there are pools of water or piles of manure or silage. Pied wagtails, too, join in the hunt for insects, while wrens may nest among old harness or huddle together for warmth in winter.
Insects abound. Silverfish and booklice feed unseen among piles of old paper, and common wasps build their papery nest in a dark corner, while an *Odynurus* wasp inserts its eggs in a suitable crack between wall and roof (they may be parasitised by the watchful ruby-tailed wasp). Spiders spin their webs on window frames or string them between farm equipment to catch unwary flies. The hay bales harbour brown rats and wood mice (animals that plunder stored grain), and their presence attracts the prowling farm cat. Under the heap of old corrugated iron a slow-worm shelters–it may hibernate there all winter.

Key to the inhabitants of the barn

1 Silverfish; **2** Booklice; **3** Dry rot on wood cladding; **4** Common wasps and nest; **5** Wasp (*Odynurus* species); **6** Ruby-tailed wasp (parasitic on eggs of *Odynurus*); **7** House spider *Tegenaria domestica* and web; **8** Spider *Ciniflo fenestralis* and sheet web; **9** House sparrows and a pied wagtail; **10** Wood mouse; **11** Farm cat; **12** Brown rat; **13** Swallows and nest; **14** Pipistrelle bats; **15** Wrens in nest; **16** Collared doves; **17** Slow-worm; **18** Barn owl; **19** House sparrow and nest; **20** Bluebottle fly caught in web.

A place for all in the barn

WARBLERS OF THE TREE CROWN

Our warblers are grouped according to whether they are birds of reed-beds, scrub or leafy treetops. Here we look at the 'leaf explorers'.

Three species of leaf warbler are found in Britain and Ireland: the willow warbler, the chiffchaff and the wood warbler. Many people find warblers of any kind difficult to identify because they are invariably well camouflaged, retiring birds. Leaf warblers provide additional problems because they look so similar to one another. A leaf warbler can generally be described as a small, greenish-brown, lightly built bird with a fine, insect-eating bill, a pale stripe above the eye and yellowish underparts, flitting about in the canopy of a tree. This description applies to virtually all the *Phylloscopus* (leaf warbler) species that occur in the Old World (there are about 30 of them). It certainly applies to Britain's three species.

The chiffchaff This, the dingiest of the three, has olive-brown upperparts and yellowish-buff underparts, an indistinct eye stripe and, usually, black legs. In keeping with its plumage and its name, its song is the least varied, alternating between two monotonous squeaky notes – 'chiff' and 'chaff'. Sometimes one note predominates as the bird 'misses' the other.

The chiffchaff is the earliest of our summer migrants: the harbinger of spring. The first birds arrive in early March, the last in April or May. However, this pattern is complicated by the tendency of an increasing number of chiffchaffs to overwinter in southern England. Although these hardy individuals may fly north to Scandinavia and beyond to breed, they are usually still here when the British breeders arrive.

The chiffchaff requires both bushy undergrowth for its nest, and tall trees as song-posts and feeding sites. While it can therefore live in well-grown deciduous and coniferous woodland, it is excluded from many areas where tall trees are uncommon, particularly parts of northern England and Scotland.

The willow warbler This bird is greener above, and more yellow below, than the chiffchaff; it has a stronger eye-stripe and, usually, pale legs. The overall impression it gives is of clearer colours and a 'cleaner' appearance.

The first willow warblers to arrive, usually in mid or late March, signal that the spring influx of visiting birds is under way. Their song is one of the most welcome country sounds, especially as it typically rings out from the heart of a colourful pussy willow tree on a bright sunlit morning. Starting quietly, the musical warbling gains volume and pitch and then descends back down the scale to a deliberate final flourish.

In its choice of habitat, the willow warbler is the least fussy of the three leaf warblers. Almost any wooded or open bushy area is suitable, provided the canopy is not too dense. Ideal habitats range from damp areas with willows (as its name suggests) to young conifer plantations and small copses. The

Above: A willow warbler sings amid the opening buds. Besides the warbling song, the bird has a faint 'hoo-eet' call. The chiffchaff also has a similar call, sung slightly faster.

Below: Plentiful down surrounds the eggs in a willow warbler's nest. All three leaf warbler species usually lay 6 or 7. Only the females incubate, and this takes 13 days. The young fledge within 2 weeks, so sometimes there is time for a second brood.

willow warbler is the commonest and most widespread of all our summer visitors, breeding throughout Britain and Ireland, even in sites close to built-up areas.

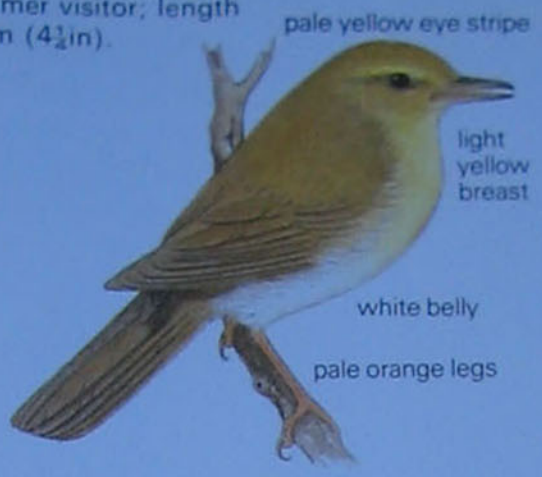
The wood warbler Of the three leaf warblers, this is the most brightly coloured, having yellowish-green upperparts, a sulphur-yellow throat and breast, a white belly, a noticeable yellow eye stripe and pale legs. At 12.5cm (5in) long, it is also noticeably larger than the other two leaf warbler species, for they each measure only 11cm (4¼in) in length.

The wood warbler is the last of the three leaf warblers to arrive, mainly between mid-April and mid-May. Full appreciation of its song is certainly only achieved when you can both see and hear the bird in action. Starting with a steady 'stip, stip, stip', it accelerates to a marvellous, far-carrying trill which sets the whole bird quivering with the effort involved. The wood warbler also has a second, less well-known though equally distinctive song: a piping 'piu' repeated several times in quick succession.

The wood warbler is very particular in its choice of habitat: it prefers mature oak, birch, beech and chestnut woodland with little or no undergrowth. The sessile oak-woods of the valleys of western Britain are ideal, but this type of habitat is not common elsewhere. Consequently this species is the least widespread, being scarce or absent from wide tracts of England and Scotland. For every one of our breeding wood warblers, there are about ten chiffchaffs and a hundred willow warblers.

The breeding season Males of all three species typically arrive to set up territories a week or two earlier than their mates, often in the same area in which they were raised. Their beautiful, domed nests, almost spherical with the entrance at the side, are solely the work of the females. Leaves, grass, stalks, moss and perhaps bracken comprise the main structure, but whereas the wood warbler lines its nest with fine grass and hair, the other two use feathers. Each species hides its nest among low-growing plants and bushes. The chiffchaff builds its nest a foot or two above the ground in most cases, while the others make

Willow warbler (*Phylloscopus trochilus*). Summer visitor; length 11cm (4¼in).



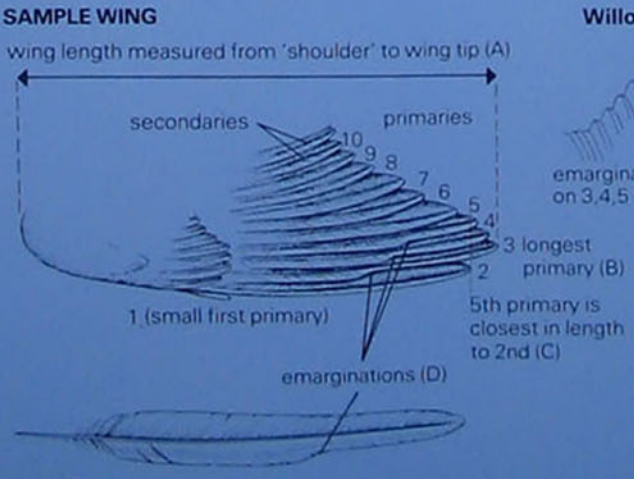
Chiffchaff (*P. collybita*). Summer visitor; 11cm (4¼in).

Wood warbler (*P. sibilatrix*). Summer visitor; 12.5cm (5in).

Wing formulae

Wing formulae are a series of measurements made to prove the identity of a bird such as a leaf warbler. In some cases, the first measurement alone is sufficient, but in others as many as four are necessary:

A How long is the wing?
B Which primaries (or primary) are longest?
C Which primaries have the same (or nearly the same) length as the second?
D Which primaries have an emargination?



Above: The chiffchaff is the least colourful of the three leaf warblers: its upperparts are olive brown.

Left: The wood warbler has brighter plumage than the other two species. Its nest is made at ground level and is domed, with the entrance at the side.

Below: The chiffchaff's nest is normally sited above ground level in the shrub layer; the bird is dependent on bushy undergrowth for nest sites.

theirs at ground level among grass and dead leaves.

Moult strategy One of the most distinct differences between our three leaf warblers, though perhaps the least obvious to the casual observer, is the timing of their feather moults. The only feature they share is that the young birds of all three species undergo a partial moult in autumn before they leave this country. (A partial moult is when the birds replace their body feathers, but not their wing or tail feathers.)

After this stage, chiffchaffs undergo a partial moult each winter and a complete moult each autumn; wood warblers undergo a complete moult each winter and a partial moult each autumn; and willow warblers undergo two complete moults, one in winter and one in autumn. To moult the entire plumage twice in each year is highly unusual, and so the willow warbler is in a class of its own in this particular respect. Curiously, there seems to be no obvious advantage in this behaviour, for all three strategies are demonstrably successful.

End of the season Late summer is the time when each individual bird must find extra food to fatten itself. This facilitates the growth of new feathers after the moult, and then fuels the bird's migration journey south. Leaf warblers are quick and agile birds, hopping to and fro to pick up tiny insects and caterpillars from twigs and leaves, hovering to catch those out of reach or darting out to intercept them in flight. At this time of year, berries provide additional variety, and those chiffchaffs that stay for the winter occasionally visit bird tables for fat, meat, bread and other household scraps.

It is remarkable that such tiny birds, weighing some 10g ($\frac{1}{3}$oz), are able to fly to winter quarters as far away as Africa. Migration begins as early as the end of July. The first to leave are willow warblers, which migrate to tropical west Africa, some even crossing the equator. Most wood warblers migrate up the Nile valley to southern Sudan. The last to leave are the chiffchaffs, many of which fly no further than the Mediterranean.

COMMON LOBSTERS: A VALUABLE CATCH

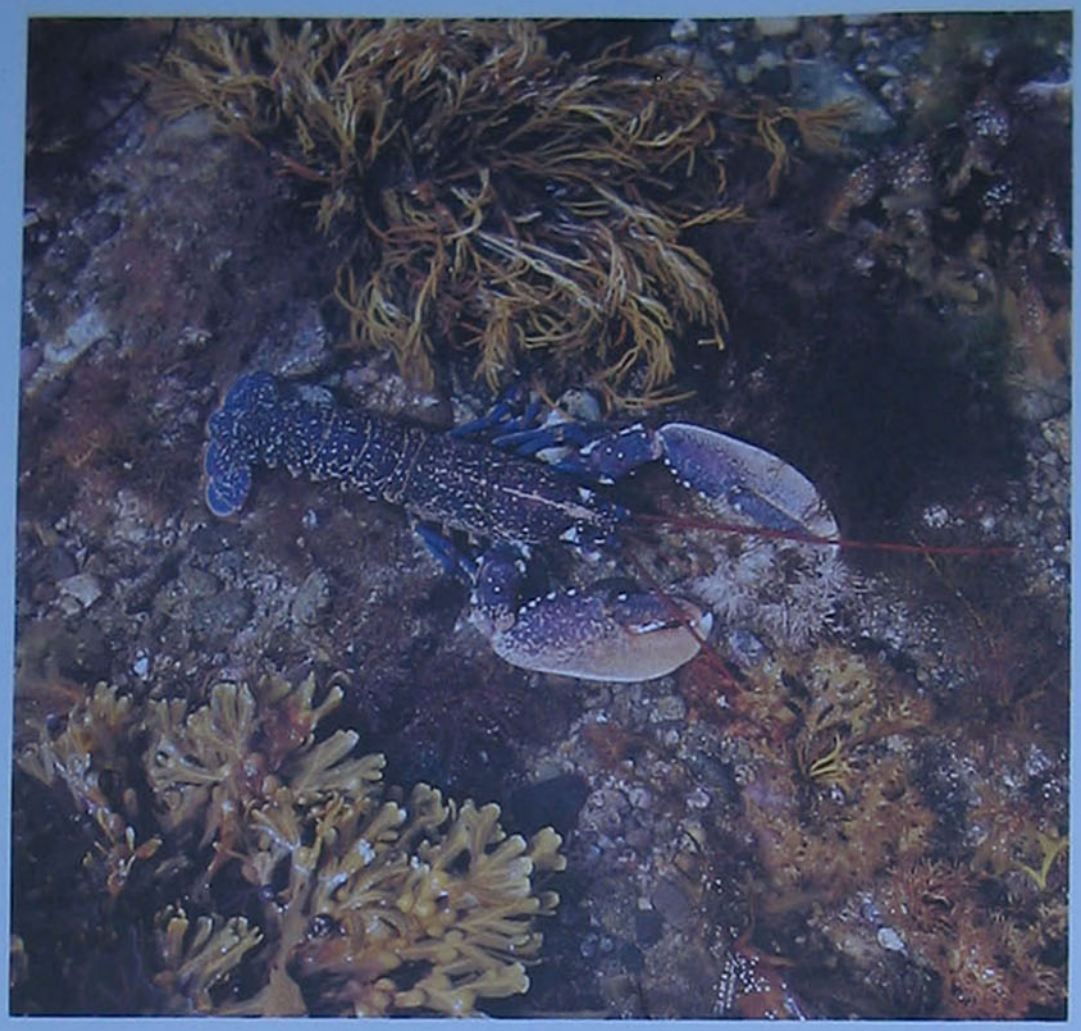
Commercially, the common lobster is one of the most important crustaceans occurring on the coasts of Britain and Ireland. Here we look at the life of this armoured creature of the rocky sea-bed, as well as at the industry that has arisen to exploit it.

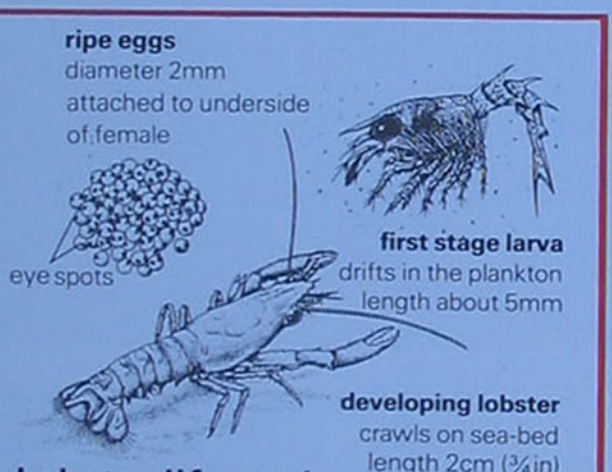
The common or European lobster is found from the Arctic Circle to Morocco and into the Mediterranean, but its main centre of distribution is around the coast of the British Isles. Lobsters are usually found on rough or rocky ground from the intertidal zone to depths of about 110m (60 fathoms).

Lobsters are territorial animals, usually living in a crevice or underneath a rock, where they spend much of their time, coming out to

Above: A common lobster leaves its hiding place in a crevice among the rocks.

Right: Although the common lobster's distribution ranges from the Arctic Ocean to North Africa, it is most abundant in our coastal waters, giving rise to important fisheries.





Lobster life-cycle

Lobsters begin life as eggs, attached to the underside of the mother. The larvae that hatch are planktonic creatures, floating in the sea. After the third moult they sink to the sea-bed; at this stage they begin to resemble their parents.

Above: A common lobster lies with its claws extended. Each claw has its own specific function. One has serrated edges which overlap scissor fashion, and are used for cutting and tearing. The other claw is more heavily built and the two edges meet directly together to form an efficient crusher. The first two pairs of walking legs also have small pincers, which are used to pick up food and pass it to the mouthparts. The food is cut and torn into smaller particles by the mouthparts. From here they pass into the stomach, which has special grinding 'teeth' (ossicles) in a structure known as the gastric mill.

feed mainly at night, when their activity is increased considerably. They feed on fishes, marine worms, molluscs, crustaceans and starfishes.

Lobster structure The lobster is completely enclosed in an exoskeleton (outer shell) of calcified chitin. The body is composed of a combined head and thorax (enclosed in a large shield-like structure known as a carapace) and an abdomen of six articulated segments. The most easily recognised features are the large claws (chelae), used for tearing and crushing food. There are eight walking legs.

The lobster also has a long pair of antennae which are sensitive to vibrations, and shorter antennules which detect chemicals. Compound eyes lie on either side of a hard, forward-pointing feature known as the rostrum. Lobsters usually walk, but they can escape rapidly backwards if threatened, by suddenly flexing the abdomen. The sex of a lobster can be determined by the different shape of the sexual appendages, which are situated underneath the abdomen. In addition, the male lobster has larger claws and a narrower abdomen.

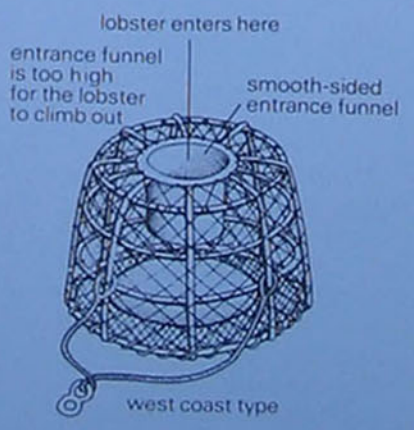
Moulting to grow The common lobster can grow up to 8kg (18lb) in weight, although such a weight would be unusual today. The rigid shell must be cast off or moulted at intervals so that growth can take place. Prior to each moult a new shell develops beneath the old one before it is cast. When moulting is about to take place, the lobster retreats into hiding, because after moulting it is soft-shelled and defenceless, and easy prey for such fishes as cod, dogfish and conger eel.

At the start of moulting, the membrane between the carapace and the abdomen splits; the soft-shelled lobster then 'jack-knifes' out of the old shell by a series of contractions. The first part of the soft lobster to emerge from the old shell is the portion at the back of the carapace and the top end of the abdomen, followed by the legs, claws and abdomen.

After emerging from its old shell, the lobster's new shell is very soft, wrinkled and pliable; it then swells up to its new size, mainly by the lobster taking in water beneath the shell. The new shell gradually hardens by a

Traps for the unwary

There are a number of local variations of lobster pot, but in general they fall into two main types. The creel (far right) has one or more side entrances, and is used mainly in Scotland and along the east coast of England. The inkwell type (right) has a single top entrance, and is used on the west coast. Fish bait is placed in the interior of the pot, gurnards, plaice and salted mackerel being the species most commonly used. Lured towards the pot by the bait, the hungry lobster climbs inside one of the entrances, but has difficulty escaping because of the constriction and shape of these entrances.



build-up of calcium salts. The shell becomes rigid within a few days, but is not completely hardened for three or four weeks.

Life-cycle Mating takes place between a soft-shelled female and a hard-shelled male. Occasionally soft-shelled males mate, but it is thought unlikely that these pairs will be fertile. The female retains sperm from the male in a special receptacle until she lays the eggs, usually about four months after mating. When it is time for her to lay eggs, she lies on her back and curls her tail forward, extruding the eggs on to her abdominal appendages or swimmerets. The eggs remain attached to the hairs on the swimmerets for approximately ten months, and a female carrying eggs in this way is called a 'berried' female. The eggs may number between 5000 and 100,000 depending on the size of the female.

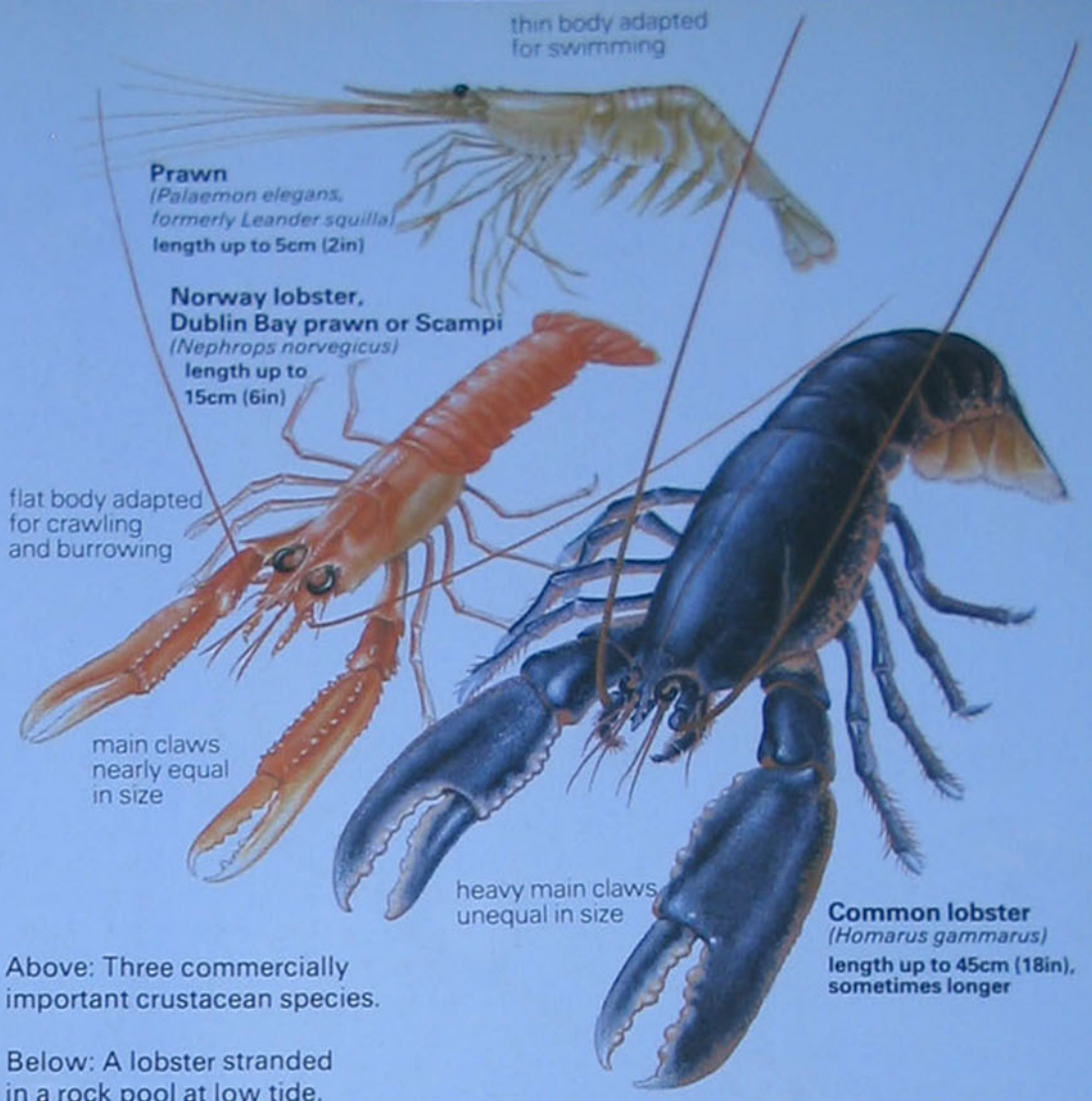
The eggs usually hatch in June or July, and the young lobster larvae that emerge are released into the plankton to fend for themselves. The larvae moult three times, changing their form with each moult. After the third moult, they spend most of their time on the sea-bed, beginning to resemble their parents.

Lobster fishing Lobsters are caught all round the coast of Britain and Ireland wherever the sea-bed is rocky. Lobster and crab fisheries are usually on the same grounds, but often only one of the two species is the main catch of a particular area. Most lobsters are caught within 8km (5 miles) of the coast, but in recent years there has been a tendency to fish further offshore, particularly in the English Channel and around the Channel Islands where boats have made substantial catches up to 65km (40 miles) offshore. The main catches are made from May to October.

The type of boat employed in lobster fishing depends on the available harbour facilities and on local weather conditions. Generally there are two types: the small open boat of between 4.5 and 9m (15-30ft) and the larger, decked boats of up to 18m (60ft). The larger boats tend to be employed in the offshore lobster fisheries and work on a seasonal basis, perhaps trawling for the rest of the year.

Handling the catch When lobsters are caught, the undersized ones–those that have not yet bred and are needed to conserve the stocks in the fisheries–are returned to the sea. Lobsters big enough to be sold are stored on board. The national minimum permitted landing size for lobsters is 8.3cm (3¼in) carapace length (the length measured from the rear of the eye socket to the rear end of the carapace, along a line parallel to the mid-line of the body shell). Egg-bearing females are not protected by legislation, although many fishermen believe that this is an essential conservation measure.

Catches made by the larger boats are normally landed and sold on the same day, but catches made by the smaller boats are often held in store pots. In some areas there are shore storage sites.



Above: Three commercially important crustacean species.

Below: A lobster stranded in a rock pool at low tide.

SWOOPING HOUSE MARTINS

House martins, among the most aerial of all our birds, feed and even roost on the wing, coming down to earth only to collect mud for their nests.

The house martin is a familiar summer visitor to nearly all parts of Britain and Ireland. It is an almost entirely aerial species and is often confused with its close relative, the swallow. However, house martins' tails are more shallowly forked than those of swallows, and house martins also lack the chestnut colour seen on swallows. The crucial field mark of the house martin is the white patch on the rump, which is very prominent when the bird is flying. The sand martin, our third member of the hirundine family, is brown, in contrast to the metallic blue of the house martin. (The swift, though superficially similar to the hirundines, is much larger and lacks the white rump: also, it has an even smoother, narrower 'sickle' shape in flight than any of the hirundines.)

Both the swallow and the house martin build nests of mud, plastered on to the walls of buildings or the ends of rafters. The structure of these two birds' nests is quite different, however. The swallow's nest is a simple cup, generally placed inside a building rather than on the outside. The house martin produces a rather more elaborate structure, generally on the outside of a building: when complete, this forms an almost complete quarter globe with a narrow slit entrance on the outside top edge.

Spring arrival The first sightings of house martins each spring generally occur in early April, but most birds do not arrive until the end of this month, or early May. Stragglers continue to appear until the end of May and even during June. They are therefore later in arriving than both sand martins and swallows, but a little earlier, on average, than swifts. The first migrants search out areas where food is in good supply, and often congregate around the shores of lakes or reservoirs, for there they are able to find newly hatched insects.

The house martin's flight is not as acrobatic as that of the swallow, nor as direct and speedy as that of the swift. House martins are frequently seen hawking very high in the sky, but if the weather is cold they fly very low in the shelter of a hedge or bank. Because of their startling white rumps they are often much more conspicuous under such circumstances than the other hirundines and the swifts, all of which often feed together with them. A wide variety of aerial insects are taken, as are many species of gossamer spiders floating about in the air on threads of silk.

Mud collectors In order to build their nests, house martins must abandon their aerial life temporarily and come down to the ground to collect mud. Here they are not very agile, and walk with a pronounced 'waddle'. The mud may be gathered from the fringes of a pond, a muddy gateway or, most often, from a

Above: House martins start their nests about 7cm (3in) below the eaves and build steadily upwards. A nail in the wall is a useful keying point from which to start.

Opposite page: A multitude of house martins roosting on telephone wires before migration. They are smaller than swallows, with whiter undersides.

Left: House martins are not timid and often allow a close approach, particularly if you are in a car and they are collecting mud from a roadside puddle. Seeing them at close quarters, you can appreciate the fascinating tiny white feathers that cover their legs. If dry weather removes the supply of mud, some people do the house martins a kindness by leaving out a bowl full of a mixture of earth and water.

Above: A crowd of young house martins on telephone wires: their plumage is more mottled than that of adults. Being aerial birds, their instinctive reaction to any approaching danger is to escape into the open sky, where their speed and endurance serve them best. The wires are a perfect aerial perch, giving them a clear view all round and an easy launch into fast flight.

Left: The nest, made of many hundreds of beakfuls of mud, forms a neat quarter globe. The entrance is a slit at the top.

roadside puddle. In really dry weather nest building may be held up for weeks through lack of mud, and birds may have to fly long distances to fetch it.

Observations of nest-building house martins have shown that it takes the birds roughly a fortnight to complete a nest. Many blobs of mud tend to be lost at the very start, in the process of keying the nest to the wall. Often the birds use a nail in the wall, a gutter bracket or a window hinge as a support. The complete nest may contain roughly 500cc (30 cu in) of mud, comprising more than 2500 beakfuls. The bare mud is then lined with feathers, grasses and straw. Much of the lining material is caught in the air, but some is picked up off the ground.

The brood in the nest The female lays a clutch of four or five white eggs, which are incubated, with the help of the male, for about two weeks. The young are fed in the nest, by both parents, for 18 or 19 days before they fledge. Most pairs are able to rear two broods, and three broods are not uncommon. The young from the first clutch often help their parents to feed later young, and the whole of this extended family may live crammed into one nest. There have been records of 13 birds living together in this way. Alternatively, a new nest may be constructed as a dormitory for the fledged young.

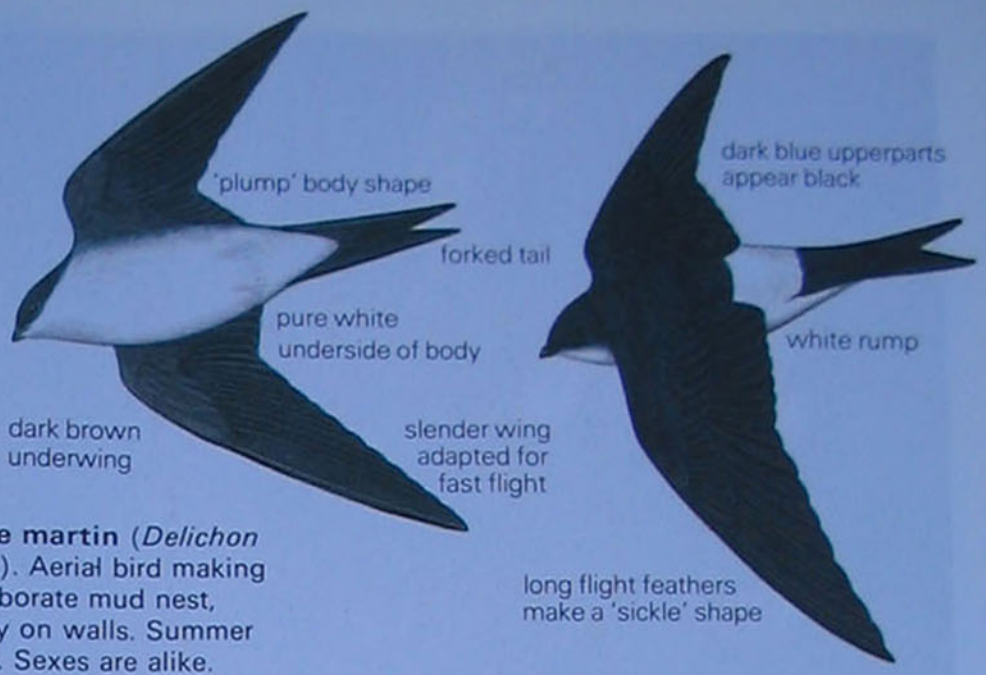
Man's dependant? In recent years, house martins have been recorded breeding much nearer the centres of many British cities than before. This is a measure of the success which the various Clean Air Acts have been able to achieve. Earlier this century, so much smoke was emitted that there were few if any of the insects needed by house martins in inner city areas.

Going back further in the history of the species, it is interesting to speculate how many (or how few) pairs of house martins there may have been in Britain and Ireland before man built dwellings on a large scale. There are certainly a handful of natural house martin colonies on coastal cliffs, in quarries and along river banks, but over 99% of all British breeding pairs now nest on buildings.

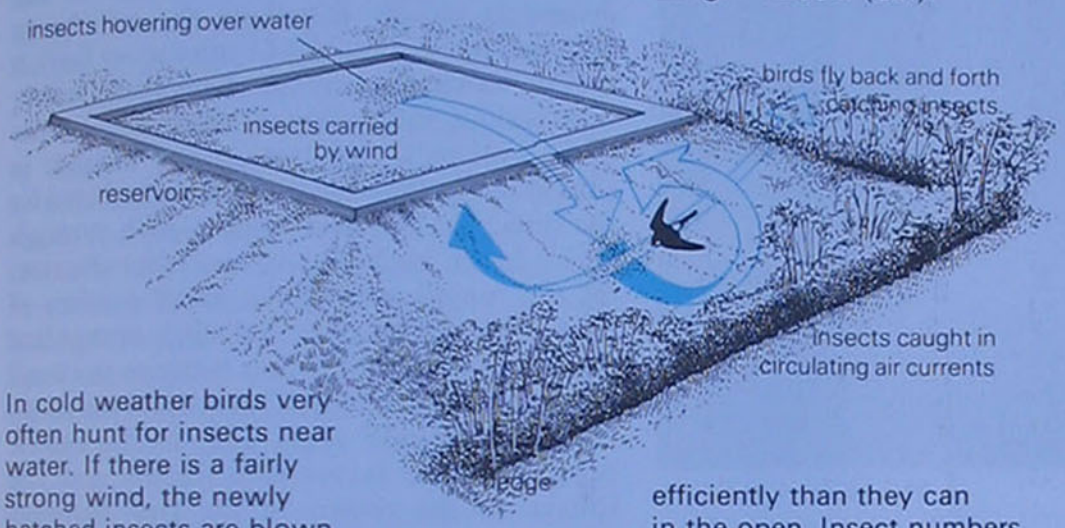
Bottom right: This cliff colony of house martins is one of the few instances where the birds manage to nest successfully without resorting to house walls. The birds here are sunning themselves; their nests are in holes within the cliff.

Below: House martins waddle on very short legs when walking on the ground to collect mud.

Feeding flocks of house martins



House martin (*Delichon urbica*). Aerial bird making an elaborate mud nest, usually on walls. Summer visitor. Sexes are alike. Length 12.5cm (5in).



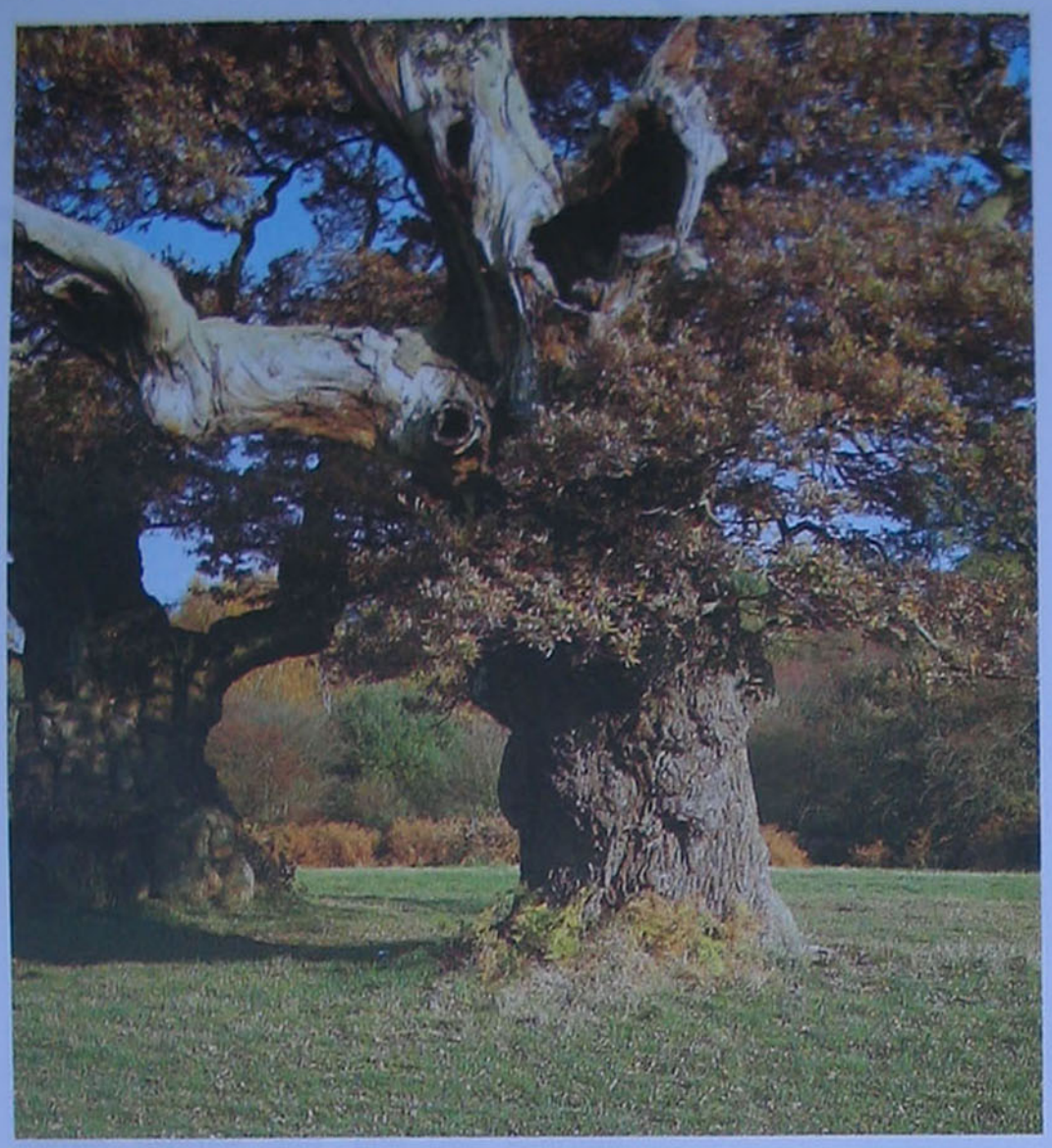
In cold weather birds very often hunt for insects near water. If there is a fairly strong wind, the newly hatched insects are blown downwind and, if there is a convenient patch of relatively still air, their numbers become concentrated. Here the birds can feed much more efficiently than they can in the open. Insect numbers in the sheltered air beside the hedge are augmented by those blown off the reservoir. Here house martins (as well as swifts and swallows) often feed.

Quite apart from nesting sites on the walls of houses, man provides the birds with two useful kinds of perches. Telephone wires are an ideal perch for such a truly aerial species, for they allow a good look-out in all directions, and also an unimpeded take-off. Small song birds react to a predator's arrival by dashing for cover, but the house martin needs the freedom of the sky.

The other man-made luxury is provided by houses whose roofs face both south-east and towards the rising sun. They absorb the early morning heat and, thus warmed, attract hundreds of sunning house martins.

Autumn departure Like other aerial feeders, house martins are forced to migrate from Britain and Ireland by the cold weather of the winter, which denies them sufficient insect food. The first movement of autumn passage birds through Britain is seen in August. Some roost in unoccupied nests at colonies which they pass, but it is almost certain that most of them roost on the wing–while their flight muscles are active, much of the rest of the bird is at rest. By September, large gatherings of house martins are seen on telephone wires and south-facing tile roofs. These continue to form until October in mild years, for some adults are still able to raise and feed late broods even in autumn.

Rather little is known about the house martins' migration routes, for few have been found abroad with rings from Britain or Ireland. The early stage of the journey, through Europe, is routed through France and (in general) Spain, later reaching North Africa. There are no records of British house martins south of the Sahara, but Continental birds reach tropical West Africa and may possibly fly even further south. In their wintering habitat, not being dependent on houses for nesting, the birds are less frequently in contact with man than in the breeding season. This is the principal reason for our lack of knowledge about this stage of the house martin's life.



TREES AND FUNGAL ATTACKS

Trees can live to a greater age than almost any other plant–sometimes to a thousand years or more. Yet even they succumb to decay and, eventually, death as one of many possible fungal diseases takes hold and attacks the heartwood.

The chance of a tree seedling reaching maturity is extremely remote: only one in a thousand survives the first year and only one in ten thousand lives long enough to bear seed. Furthermore, a young tree faces adverse conditions such as wind, drought and fire, competition from other plants and damage from fungi and animals.

Despite all this, trees 100 or 200 years old are fairly common, but specimens older than that become increasingly rare. Various factors influence the age to which a tree might live. Hardness of wood, speed of growth and favourable conditions and habitat all play their part, as do the different ages at which different species mature. Birches, for example, reach maturity at about 50 years old, beeches mature at twice that age and oaks at 150 years old. (Maturity is said to be the time when a tree stops increasing in height and its annual increase in girth becomes minimal, though without actually ceasing.)

Once a tree reaches maturity the presence of lignin and antiseptic chemicals in the heartwood protects it from decay for perhaps hundreds of years. Eventually, however, spores of fungi force an entry into the tree through a wound of some sort–where a branch has broken off perhaps, or where an insect has attacked the sapwood. Once that happens, the tree becomes diseased and goes into a gradual decline which can end only with its death.

Beech bark disease An example of a fungus that attacks in this way is beech bark disease (*Nectria coccinea*). The initial stage of the disease is closely linked to the tree being attacked by beech scale (*Cryptococcus fagi*), a minute sucking insect that attacks only beech.

A serious infestation of scale can, on its own, weaken a tree but greater damage is caused by the fact that the wounds inflicted by the insect on the bark open a path through which beech bark disease can enter the tree. As the fungus gains hold, small patches of bark die; if peeled away, a distinct orange line can be seen at the junction between the dead wood and the live wood. Sometimes sap flows from the infected areas and, as the attack progresses, the leaves turn yellow and the foliage in the crown of the tree becomes sparse. A severely affected tree dies within a few years.

Honey fungus Not all diseases are specific to one species of tree. Honey fungus (*Armillariella mellea*) attacks a wide range of hosts and even species that are resistant to

Above: Few species of trees regularly produce individuals that live for more than a few hundred years. In Britain the two exceptions to this are oaks (such as the Hollow Oak in Windsor Great Park shown here), which often exceed 500 years, and yews, which may live for 1000 years.

Right: This bracket-shaped fruit body is an outward sign that the heartwood of the birch tree is being attacked by the heart rot fungus.

attack, such as oak, can be killed indirectly by honey fungus weakening the roots so much that the tree is blown over during a gale. Nor does honey fungus need an insect to allow it entry to the tree.

The fungus gains its name from the colour of its toadstools, but it exists largely as a mass of microscopically fine hyphae growing within the roots and stumps. Beneath the bark the hyphae are abundant enough to form a creamy-white fungal mass called a mycelium, which is clearly visible and looks rather like a thin sheet of paper spread over the inner wood. Sometimes the hyphae aggregate into thin black strands which either develop beneath the bark or spread out through the soil to infect host trees near by.

Sooty bark One disease has become a major killer only since the very hot summer of 1976, and that is sooty bark disease of sycamore (*Cryptostroma corticale*). At present it is limited to a area within a radius of about 300km (200 miles) of London.

This disease, which causes a dark, dry patch to appear just under the outer bark, has spread under the effect of two factors. The major factor is the weather–warm summers favour severe attacks while cool weather acts as a natural control. The other factor is more local in its effect. The grey squirrel feeds on the fungus and it also strips bark from sycamore trees, thus spreading the disease.

Heart rot The familiar bracket fungi so often seen on the boles of birch trees in summer and autumn are the outgrowths of a serious disease that will eventually kill the tree. This disease is heart rot fungus (*Piptoporus betulinus*) and it attacks birches already damaged in some way.

The fruit body (ie, the bracket fungus) has a pale brown upper surface with white flesh that is soft at first and then becomes corky. Pores on the underside release numerous minute spores–too small to be seen except as a fine dust–that disperse to infect further hosts. Eventually the wood of an attacked birch turns reddish-brown and breaks up into dry rectangular blocks, each separated by thin sheets of white mycelium. In the final stages of the disease, branches and even trunks of the affected tree are liable to snap without warning.

Sooty bark of sycamore

This disease attacks sycamore trees, causing a dry sooty layer, olive to brownish-black in colour, to appear just beneath the outer bark. This sooty layer consists of spores which disperse to expose a greyish layer. This in turn eventually turns black. Shown here are infected bark (far left) and healthy bark (near left).

Beech bark disease

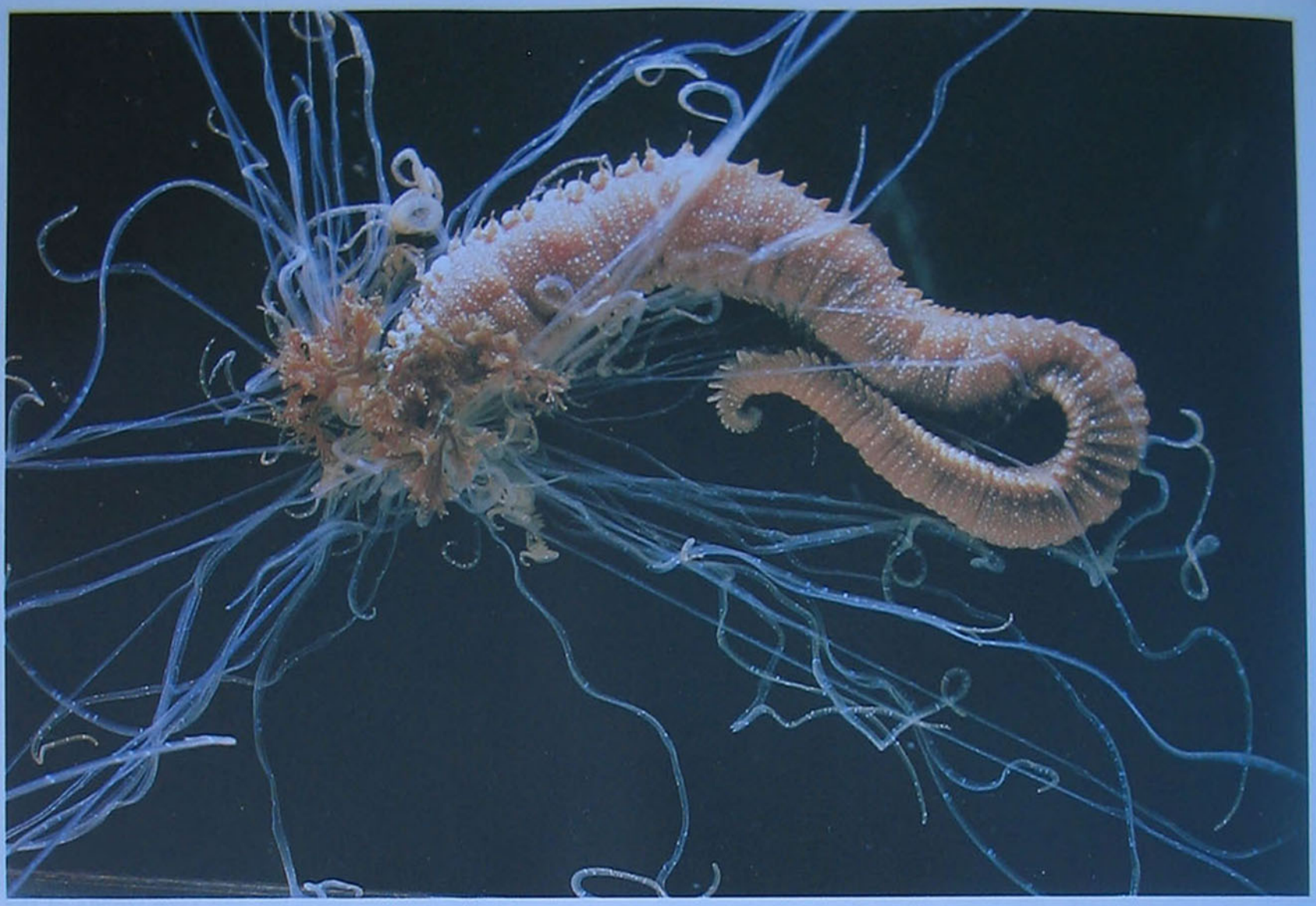
Beech scale
(Cryptococcus fagi)

Beech bark disease enters through wounds caused by beech scale, a tiny insect (left) covered with a dense white waxy secretion. Healthy bark and an infected patch are shown mid and far left, respectively.

Below left: Heart rot in a felled oak. As the heartwood rots away it becomes no longer capable of supporting the tree, which is then susceptible to being blown over during a gale.

Right: The toadstools of honey fungus vary greatly in size and shape, but they can be distinguished by their honey-brown colour. They can often be seen in clumps at the foot of trees from summer to early winter.

Below: Honey fungus is sometimes known as the bootlace fungus, a reference to one of its most characteristic features –the thin black strands called rhizomorphs that grow through the soil to spread the disease.



COMMUNITIES OF SEA-BED SEDIMENT

Off the shores of the British Isles are vast areas of underwater mud, sand and gravel. The surface of these sediments appears bare when compared with the rocky sea-bed, but within are huge numbers of worms, molluscs, crustaceans, brittle stars and sea urchins.

Since most of the animals dwelling in the sediment of the sea-bed are burrowers, it is difficult to gain a true idea of the numbers that actually exist. The only way to observe these animal communities is to sample the sediment, then wash away the mud and sand over a sieve, so exposing the animals to view. Research shows that the macrofauna (animals larger than 1mm) alone can number 80 species and 2500 individuals below just one square metre of sea-bed.

The discovery of 'communities' In the early part of this century CGJ Petersen (an eminent Danish fisheries scientist) began a series of investigations in the Danish seas that were intended to provide a basis for calculating the quantity of fish food available for bottom-living fishes. As he worked on the thousands of bottom samples collected it became clear to Petersen that animals were not distributed in a random fashion; distinct assemblages of organisms existed which could be characterised by a few large or abundant species. This definition, though adapted, altered and criticised, is a basis for most present descriptions of sea-bed communities. It was clear to Petersen and to later researchers that the collection of animals present was dependent mainly on sediment type, so it is little wonder that the naming of the communities has taken two main lines, one naming the communities by their dominant or character-

Above: This type of polychaete worm is abundant in the bivalve mollusc *Macoma* community found in shallow water muddy areas extending on to the shore.

Right: The heart-urchin or sea potato (*Echinocardium cordatum*) belongs to the sand-dwelling community, and is found in depths of 10-20m (33-66ft) below the sea surface. Shown here are the urchin's upper surface (left) and the under surface (right).

istic species, the other by the sediment type they occupy.

North-east Atlantic communities Four sediment communities are particularly widespread in this area. In the shallow water muddy areas extending on to the shore, a community characterised by the bivalve mollusc *Macoma baltica* is usually found. Often the most conspicuous species, to the casual observer, are the lugworm *Arenicola marina*, visible only by its casts of excreted material, and the edible cockle, which lives very near the surface. The netted whelk (*Hinia incrassatus*) ploughs through the surface here, searching for bivalve molluscs such as *Macoma* to bore into and feed on. The deeper into the sediment an animal can burrow, the more protected it will be. All the species living below the shallow surface layers, often in deoxygenated sediment, need a connection to the surface, either in the form of an open burrow or by a long siphon such as that possessed by another bivalve inhabitant of this community, *Mya arenaria*. There are many small amphipod crustaceans and polychaete worms in a community such as this, and the worm *Pygospio* is often abundant, with the small mud tubes in which it lives packed closely together at the surface.

The *Chamelea* (or *Venus*) community is found in depths of about 10-20m (33-66ft) below the sea surface in sand. Here, the bivalves *Chamelea gallina* and *C. ovata* are present in large numbers, together with several other bivalve species, many of them important sources of food for fishes. The polychaete *Pectinaria* also lives in this community and constructs a tapered tube of sand grains in which it sits head down into the sediment, drawing water and food into its burrow. The heart-urchin, too, lives buried in the sediment. Apart from the fishes and other surface dwellers, there are predators within the sediment, including the starfish *Astropecten irregularis* and species of the snail *Lunatia*.

A third community can be found in muddy sand in depths of about 5-15m (16-50ft); this habitat is populated by vast numbers of bivalves of the species *Abra* (or *Syndosmya*). These molluscs, together with many of the other species in the *Abra* community, are fast-growing and provide a source of rapidly renewed food for flatfishes such as plaice and flounder. Large brittle stars (*Ophiura texturata*) are often common here.

In deeper water from about 15-100m (50-330ft) the muddy sea-bed is colonized by a rich community characterised by species of burrowing brittle stars (*Amphiura*), together with the urchin *Brissopsis lyrifera* and a wide range of polychaetes and crustaceans. To the observer swimming over the sea-bed, the arms of *Amphiura filiformis* appear as a meadow of rather sparse long grasses which rapidly withdraw if touched. A fascinating and unusual species often present in this com-

Four sediment communities

The *Macoma* community

1 lugworm *Arenicola marina*.
2 Edible cockle (*Cerastium edule*).
3 Common shrimp (*Crangon crangon*).
4 Netted dog whelk (*Hinia reticulatus*).
5 Bristleworm *Pygospio*.
6 Bivalve *Macoma baltica*.
7 Bivalve *Mya arenaria*.
8 Mud snail *Hydrobia*.

The *Chamelea* community

1 Heart-urchin or sea potato (*Echinocardium cordatum*).
2 Starfish *Astropecten irregularis*.
3 Snail *Lunatia*.
4 Common prawn (*Palaemon serratus*).
5 Striped Venus shell (*Chamelea gallina*).
6 Bivalve *Spisula elliptica*.
7 Bivalve *Tellina fabula*.
8 Bristleworm *Pectinaria* species.

The *Abra* community

1 Blunt gaper shell (*Mya truncata*).
2 Common whelk (*Buccinum undatum*).
3 Bivalve *Abra* species.
4 Bristleworm *Pectinaria* species.
5 Brittle star *Ophiura texturata*.
6 Bivalve *Cultellus pellucidus*.
7 Bivalve *Nucula* species.
8 Common basket shell (*Corbula gibba*).

The *Amphiura* community

1 Sea urchin *Brissopsis lyrifera*.
2 Tower shell (*Turritella communis*).
3 Brittle star *Amphiura chiajei*.
4 Pelican's-foot shell (*Aporrhais pes-pelecani*).
5 Brittle star *Amphiura filiformis*.
6 Sea pen *Virgularia mirabilis*.
7 Bristleworm *Nephthys ciliata*.

munity is the sea pen *Virgularia mirabilis*. It grows to a height of up to 30cm (12in) above the sea-bed and, as a close relative of the sea anemones, the stalks are covered in anemone-like polyps. The sea pen extends for a similar length down into the sediment and is firmly anchored by a bulbous foot. The tower shell (*Turritella communis*) and the pelican's-foot shell (*Aporrhais pes-pelecani*) have unusual shells and are often found in this habitat.

Two plant communities Most communities are described according to the conspicuous burrowing animal present, but some marine algae can use relatively small pieces of gravel as a substratum for growth and, provided the gravel is stable for at least a few weeks, form

Below: A characteristic inhabitant of coarse gravel is the burrowing sea cucumber *Neopentadactyla mixta*. If often occupies substrata which are highly mobile. The body of this creature, which is about 10cm (4in) long, is buried but the sticky tentacles appear above the sediment to catch suspended particles of organic matter. Each tentacle is withdrawn into the mouth one after the other to suck off the attached material.

characteristic assemblages in the shallow well-lit zones during the summer. However, multicellular plants are not generally found on sediments because there is no firm base for attachment on the sediment particles.

There are, nevertheless, two remarkable exceptions to this rule: the beds of eel-grass (*Zostera marina*) which occur in shallow, sheltered waters (usually no deeper than 5m/16ft), and the beds of maerl (detached calcareous algae) which make up large areas of the sea-bed and also occur in sheltered conditions, particularly those off the west coasts of Ireland and Scotland. *Zostera marina* is the only flowering plant which inhabits sublittoral areas of the British Isles. Rhizomes of the plant provide a firm anchorage into the sediment, and the leaves, which can grow to over a metre in length, form large meadows which are habitats for a variety of fishes and attached algae and invertebrates.

Maerl (*Phymatolithon calcareum* and another red algae, *Lithothamnion corallioides*) often occurs with *Zostera*, but also forms extensive beds deeper than the *Zostera*. The pink calcareous nodules are usually 1-3cm ($\frac{2}{3}$-1in) across but grow up to 10cm (4in), forming a substratum like coarse gravel. Only a proportion of the maerl is alive but the dead material remains to form deep beds which are exploited as a source of limestone fertiliser in some areas. Many rare or unusual species occur in this habitat, which has a very restricted distribution.

Below: The common starfish (*Asterias rubens*) is another inhabitant of the muddy gravel habitat. Along with a few crabs and fishes, it is one of the few species to be seen on the surface of the sediment.

Food and feeding Most of the animals living in the sediment rely on plankton and suspended organic matter for food, taking that food by suspension or deposit feeding. Suspension feeders, such as some of the bivalve molluscs, draw in water through a siphon, filter off the organic material and pass the water out through another siphon. Other suspension feeders, such as fan worms, the sea pen, and those brittle stars with arms protruding from the sea-bed, catch their food as it floats past in water currents. Deposit feeders include bivalve molluscs, which use their inhalant siphon like a vacuum cleaner to draw in organic material from the surface of the sediment, and such species as the lugworm *Arenicola*, which eats large quantities of sand to extract organic material.

The animal species living in the sediment include many voracious predators. Among the larger species is the starfish *Astropecten*, which takes whole bivalves into its stomach and digests the tissue. The snail *Lunatia* has rasping teeth and probably also uses a chemical to bore a small conical hole into clam shells, into which its proboscis is inserted to feed on the animal within. Many worms are predators and such species as *Nereis* have vicious jaws, used to attack other worms. The several species of anemone which burrow into sediments are opportunistic carnivores and carrion eaters, waiting for prey to stumble into their tentacles or for carrion to come into contact. The fishes which live on or near the bottom are large consumers of sediment-living species, especially bivalve molluscs, and some duck species also dive for bottom-dwelling animals. With such a variety of predators it is hardly surprising that the long-lived species are generally those which dig

deep and are equipped with thick shells. Thin-shelled animals living near the surface, such as *Abra*, reproduce in enormous numbers and have a short life-cycle.

Reproduction, settlement and survival The majority of north-east Atlantic species living on the sea-bed have planktonic larvae which spend up to a month drifting in the surface waters, feeding on phytoplankton and on each other. Vast numbers of larvae are produced and mortality is high before the survivors are ready to settle to the bottom.

Settlement appears to be far from random. In the open sea small differences in temperature and salinity, together with other aspects of water quality, may induce or discourage growth, feeding and settlement. Thus, the survival of the larvae is different in different water bodies, and choice of settlement sites may be affected. Larvae of bottom-living species are often photopositive (attracted to light) or photonegative (repelled by light) and, at the end of their larval life, will go either near the surface and therefore settle in shallow water or to the bottom and settle in deeper water. Sensitivity to gravity or water pressure has a similar effect. The larvae of several species have been shown to select the type of substratum on which to settle. Once the larvae are on the bottom, it is a fight for survival of the fittest, including competition for living space and food and the interaction between predators and prey.

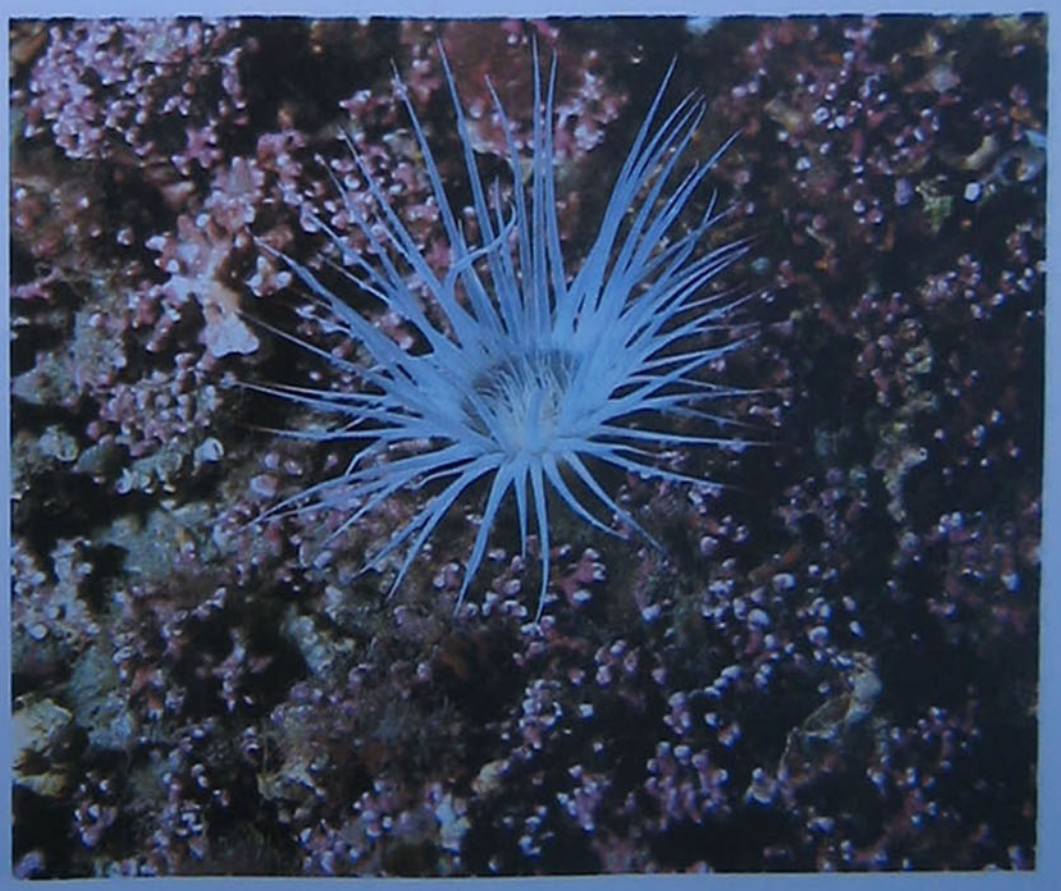
Many of the species present in the sea-bed sediment live for several years and include some of the large bivalve molluscs, large crustaceans such as the Norway lobster, and some of the echinoderms. Their survival often depends on the presence of a stable environment where sediments are not disturbed by storms or other forms of perturbation. In shallow wave-exposed areas, communities are frequently disturbed and generally consist of large numbers of a small variety of fast-growing species, particularly some polychaete worms and small bivalve molluscs. Apart from the changes resulting from storms, many sea-bed communities are very changeable, particularly because of variable recruitment of their component species or heavy predation in some years. Such changes occur in the species characteristic of more stable communities but are usually reflected in low or high numbers in particular year classes rather than in generally low or high densities. In environments where physical conditions, including such factors as wave action, temperature and salinity, are stable, the communities are usually much more diverse than those that form in unstable environments.

Any environmental change beyond the usual is likely to cause stress and result in reduced numbers of species being present (although those organisms that are stress-tolerant thrive). This is the case for both natural disturbance and man-induced disturbance, including pollution. Much work has been done to study the effects of organic pollution on marine sediment communities (in particular that caused by sewage discharge and pulp mill effluents). Pollution in the North Sea oil well area is also being studied.

Above: Eel-grass (*Zostera marina*) is the only flowering plant to inhabit sub-tidal areas of the British Isles. It usually occurs in waters no deeper than 5m (16ft). Before the 1930s it was much more abundant than it is today, but at that time a bacterial or fungal infection decimated the populations, which have still not fully recovered in many areas.

Left: The tower shell (*Turritella communis*) is often found as a member of the burrowing brittle star *Amphiura* community in mud in deep water.

Below: The burrowing sea anemone *Cerianthus lloydii* lives in a wide range of sediment types and communities.



LEAF-ROLLER AND LONGHORN MOTHS

Leaf-roller moths, the caterpillars of which roll themselves up in leaves, and longhorn moths (sometimes known as 'fairy moths' because of their dainty appearance and flight) all belong to the group Microlepidoptera (meaning small moths).

Of the 320 or so species of tortrix moths (family Tortricidae) found in Britain, many are leaf-rollers, the green oak-roller being the commonest and best known. Other familiar members of the family include the garden rose tortrix, the pea moth and the notorious pest of apple trees – the codling moth. In contrast, there are only 25 longhorn moths (Incurvariidae) found in Britain, the green longhorn being the best known, followed by the raspberry moth and De Geer's longhorn.

Green oak-roller Identifying some of the leaf-roller moths can be difficult, with some species varying so much in colour and pattern that different varieties can easily be mistaken for quite distinct species. The green oak-roller is, however, easy to distinguish from other species since both sexes have uniformly pale green forewings and glossy, pale smoke-grey hindwings.

The female green oak-roller lays her eggs in batches on oak twigs in June and July. Here they overwinter, and do not hatch until the following May, when they roll themselves up in leaves and feed from within. In June and July the pretty pale green moths emerge from the black pupae and fly around at night, although you may occasionally see one that has been disturbed from the undergrowth on the wing in daylight. Green oak-roller moths are widespread in Britain, where they are abundant in woods with oak trees, and hedgerows, particularly in the south.

Garden rose and pea moths One tortrix moth which varies considerably in colour and markings is the garden rose tortrix, a brownish-yellow species. It flies after dark from August to November and is common in gardens, hedgerows and along the borders of woods. The caterpillars may be found in spring, feeding on various trees and shrubs belonging to the rose family, and on bilberry and hazel.

Another tortrix moth, the pea moth, is a small dark brown species, on the wing from June to August. Its white caterpillars feed inside the pods of garden and wild peas, vetches and vetchlings during the summer.

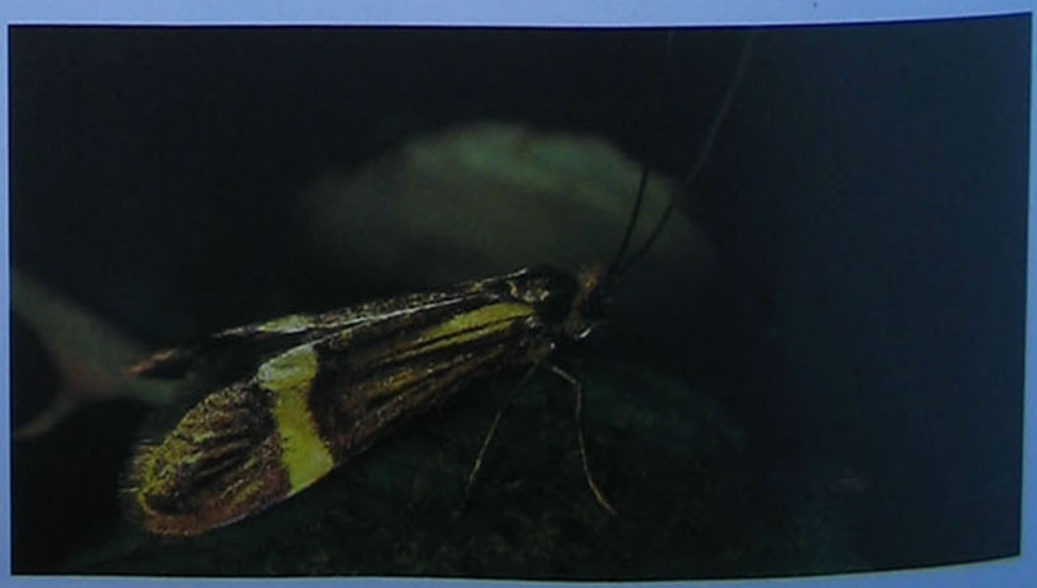
Swarming males The Incurvariidae derive their popular name 'longhorn' from the long thread-like antennae which the males, in particular, possess. Along with their prominent eyes, these antennae are believed to enable them to detect the females hiding in the vegetation.

The green longhorn moth, renowned for its extremely long antennae (they are nearly three times the length of the forewing) has brilliant bronzy-green forewings with a purple sheen along the front edges. Its hindwings are purple-black. The female differs from the male not only in having much shorter antennae, but also in having black and yellow hairs on the head, and a bronze-green thorax instead of a black one.

There is some uncertainty as to where the female green longhorn lays her eggs; while some authorities believe she inserts them into pear-shaped pockets in the midribs of oak, birch and beech leaves, others have reported seeing females deposit their eggs in stinging nettles. On hatching in September the minute caterpillars mine through the leaves, feeding for a short time before dropping to the

Above: The green longhorn moth (*Adela reamurella*) has a wingspan of 14-18mm (⅔in).

Below: De Geer's longhorn moth (*Nemophora degeerella*) is common in damp woods.



ground, possibly still in the leaf, although these details have yet to be resolved.

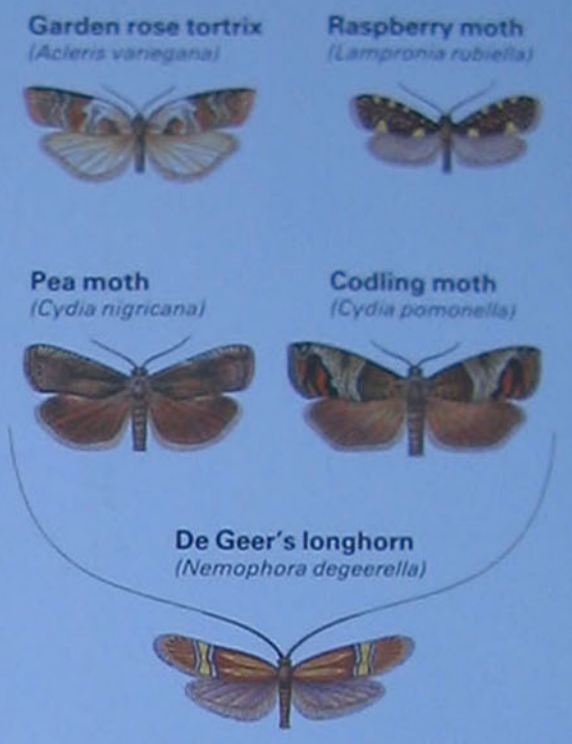
On reaching the ground the caterpillar constructs a flat portable case from leaf fragments, not unlike a spectacle case in shape. Although small, it is remarkably strong, being strengthened inside with silk. From the security of this case, the legless, pale brown caterpillar feeds on dry, fallen leaves until early the following spring, when it pupates within its case.

From April to June the male green longhorns fly in the sunshine around trees and shrubs, often in swarms (resembling gnats from a distance). These swarms usually circle around the tops of trees, although they can occasionally be seen flying low. Both sexes are abundant in woodlands and hedgerows throughout England and Wales, and probably over most of Scotland and Ireland too, although they have still to be recorded in many counties there.

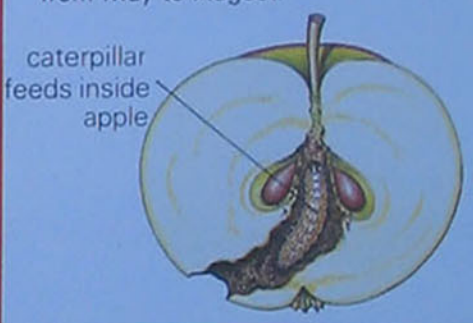
De Geer's longhorn A close and equally attractive relative of the green longhorn is

Above: The name of the green oak-roller (*Tortrix viridana*) derives from the caterpillar's habit of twisting or rolling up leaves, in which it hides (below) so that it can feed in relative safety. Nevertheless many fall victim to birds since these particular caterpillars are a principal food source for tits—a single great tit may collect as many as 300 in one day. In some years green oak-roller caterpillars exist on trees in such large numbers that they cause severe defoliation. Fortunately the trees usually recover, producing a fresh growth of leaves, although they may be rendered more susceptible to disease.

Identification parade



Below: The caterpillars of the codling moth are well-known pests of apple trees. Whitish in colour, they feed unseen on the apple pips until fully grown, when they emerge from the fruit to build cocoons on the bark. They pupate in spring and can be seen on the wing from May to August.



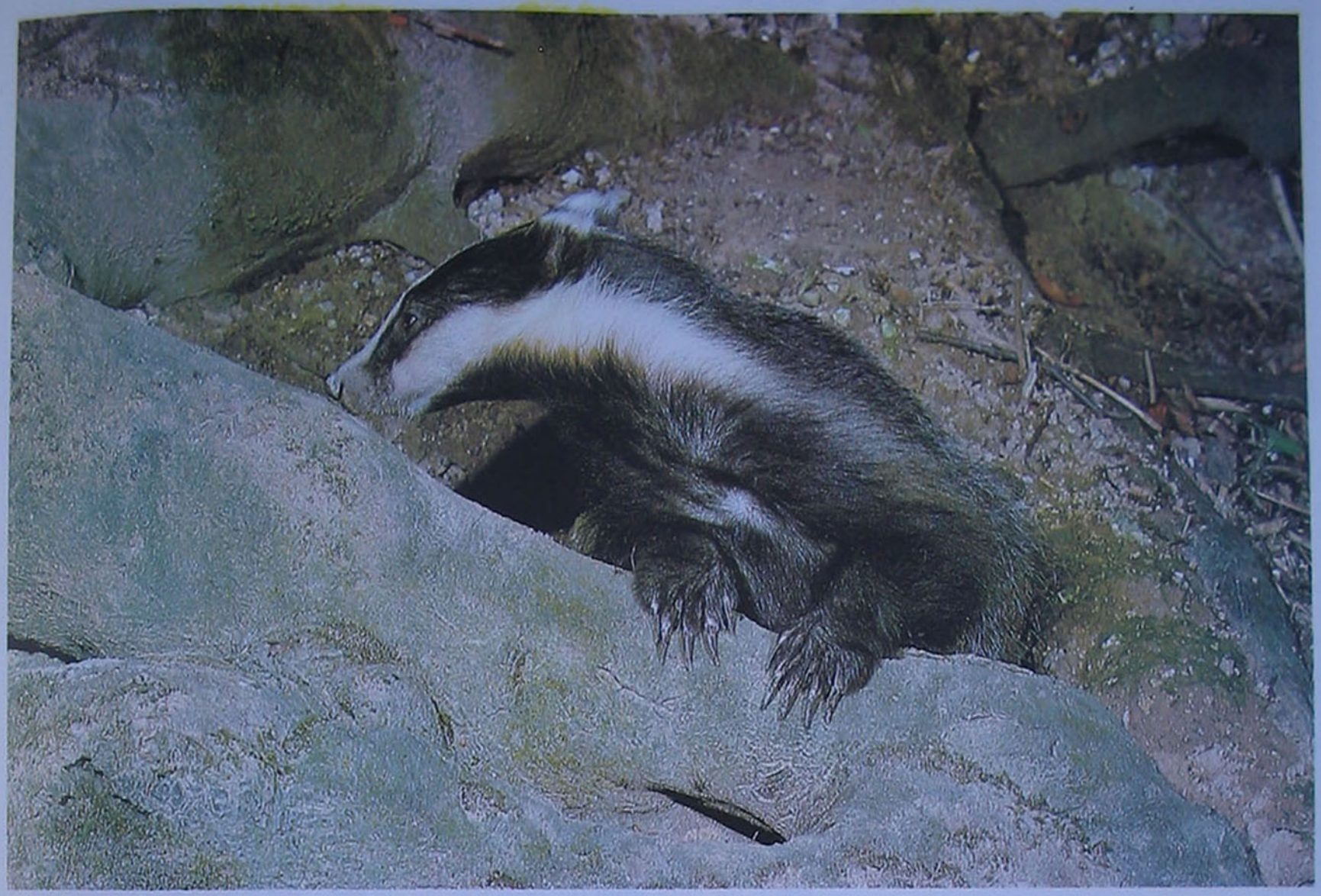
De Geer's longhorn, common in damp woods almost everywhere in England and Wales and in parts of Ireland as well. It has dark, bronze-coloured forewings, each with a yellow band bordered by deep purple.

The male's antennae are even longer than those of the green longhorn, measuring about three and a half to four times the length of the forewing. They fly in woodland clearings on sunny days in May and June, but tend to be most numerous towards dusk. In common with the green longhorn, the caterpillars live and pupate in a leafy case in the leaf litter.

Raspberry pest The raspberry moth is notorious as a pest of raspberries and loganberries almost everywhere in the British Isles, except for northern Scotland and parts of Ireland.

The adult moths fly in the late afternoon and at night from May to July, the females laying their eggs in raspberry flowers. The young caterpillars hibernate at the base of the foodplant, reappearing in the spring to attack the buds and developing shoots.

Looking at a sow badger's territory



THE STORY OF A SOW BADGER'S YEAR

This is a story, part fact, part fiction, of a sow badger. She lived in a sett in the soft red sandstone of the Brendon Hills in Somerset. In January she was nearly two years old and carrying her first litter of three tiny foetuses.

Above: The sow badger emerging from her sett. She was a few centimetres shorter than the male and probably about 1.4kg (3lb) lighter. Like all badgers, she had very strong forelimbs with long claws that were ideal for her underground life where she dug and shovelled earth.

Opposite page: A map to show the sow badger's territory and some of the places where she went to find food.

The sett the sow badger was using was one of four in a narrow copse straddling a steep bank separating fields near the farm from deeper fields below. Over the years badgers had excavated many holes along the length of the copse. Badgers are capable diggers, and this sort of soil was easy; below ground the tunnels formed an extensive labyrinth. The four setts were separate, but were seldom all occupied at the same time. All were the work of a single social group of badgers.

In early January the sow was living along with her mother in the sett where she had been born. Two adult boars were also living there, but in different parts of the sett. One was particularly large and was dominant to his younger companion. Two cubs of the previous year were living on their own in a sett further down the copse.

The group's territory covered part of a large farm and occupied about 50 hectares (125 acres). Much of the territory was pasture, but some rough scrub, a little arable land for growing oats and a small apple orchard near the farm buildings also existed. A deciduous wood bordered the territory to the south, but this was out of bounds as it was occupied by another social group. Elsewhere the boundary mainly followed the hedges.

January The year started with a mild spell; the ground was soft, the air moist and food was comparatively easy to find. It was not mild enough for earthworms to lie on the surface of the damp earth, but they were active not far below and some were easily located by scent or by the scraping sound of their bristles when they moved. A quick dig with the muzzle and a flick of the front paw was all that was needed to unearth them.

The sow emerged each night soon after dark. This was the best time for foraging because the temperature was higher and there was a greater chance of finding prey. She foraged mainly in the copse and the more sheltered pastures. She was usually back before midnight.

Towards the middle of the month it became much colder. A light fall of snow with swirling winds prevented them from going out to

hunt for food, but the clear frosty nights that followed did not deter them. Food was difficult to find, but in a dell in the copse, sheltered from the north and east, the ground was still soft. Wild arum grew here in abundance, their first green leaves projecting through the snow. Their succulent corms were a useful source of food, but first the poisonous shoots had to be nipped off and discarded. A dead blackbird under its roosting tree was an unexpected bonus and some spilled cattle food by one of the farm buildings was a useful addition. On some nights she was less fortunate, but scarcity of food over a few nights was no real problem as she still had a good supply of stored fat beneath her skin.

By the end of the month the foetuses were getting large and her teats had started to swell in readiness for suckling. She started to prepare for the birth. The chamber chosen was about 7m (23ft) in from the outside, mid-way between two entrances situated at one end of the sett. The sow's mother, who was also expecting cubs, had already staked her claim to the main sett area where she had previously given birth to cubs.

February-March One frosty morning the sow dragged out all the bedding to air in the sun for a few hours, and then dragged it back inside again. A few days later her cubs were born, two males and a female. Having licked them clean, she gently drew them into the mass of bedding, keeping them close to her warm body. For two further nights she kept close beside them, suckling frequently and not venturing above ground.

The next night was warm and wet. She was hungry, and a good meal was imperative to keep up her milk supply. She emerged with great caution, sniffing the air for some minutes for any sign of danger. Then, marking the entrance with her musk gland secretion, she went off to the nearest pasture for a rapid meal of earthworms. She was back within an hour to see that all was well and to suckle the cubs. Later that night she went out again on a longer forage.

By the time the cubs were a fortnight old a regular routine was established. To safeguard the cubs from the boar's attention she would wait until he had departed on his nightly round of dung pits on the boundary of the territory. He did this to re-inforce the scent signals against intruders. Then she would slip away to a nearby feeding ground to forage. She would make three or four excursions a night, returning for a brief period for suckling. She left the cubs buried in bedding, huddled together for maximum warmth. They were still blind, but their fur was thickening. They made quiet whickerings whenever the sow returned and she would greet them with a low, whinnying, purr.

When the boar was not patrolling the territorial boundary he would visit each sow within the social group, looking for signs of

Above: Early January—the sow was living along with her mother in the sett where she had been born, well protected in the deciduous woodland.

Opposite left: February—one frosty morning when the sun had warmed the entrance to the sett, the sow dragged out all the bedding from the breeding chamber, scattering it all around the entrance in fluffed-up bundles. A few hours later, when it was thoroughly aired, she drew it all back inside again.

Below: April—one of the cubs in its wanderings discovered the sett entrance while the sow was away. Tentatively it clambered out, sniffing all the new smells, but the hoot of an owl caused it to retreat rapidly to the safety of the tunnel.

Above: May—the sow with her cubs. By now they were bigger, stronger and more adventurous. They joined up to play with the cubs born to the sow's mother.

Above right: June—the sow collected quantities of freshly cut hay to furnish the underground chambers. The excess formed an enormous heap outside one of the entrances, and it made a good day nest.

Below right: July—the oats were ripening and a useful source of food; and (below) the playing tree was an ideal place for scratching and frolicking throughout the year.

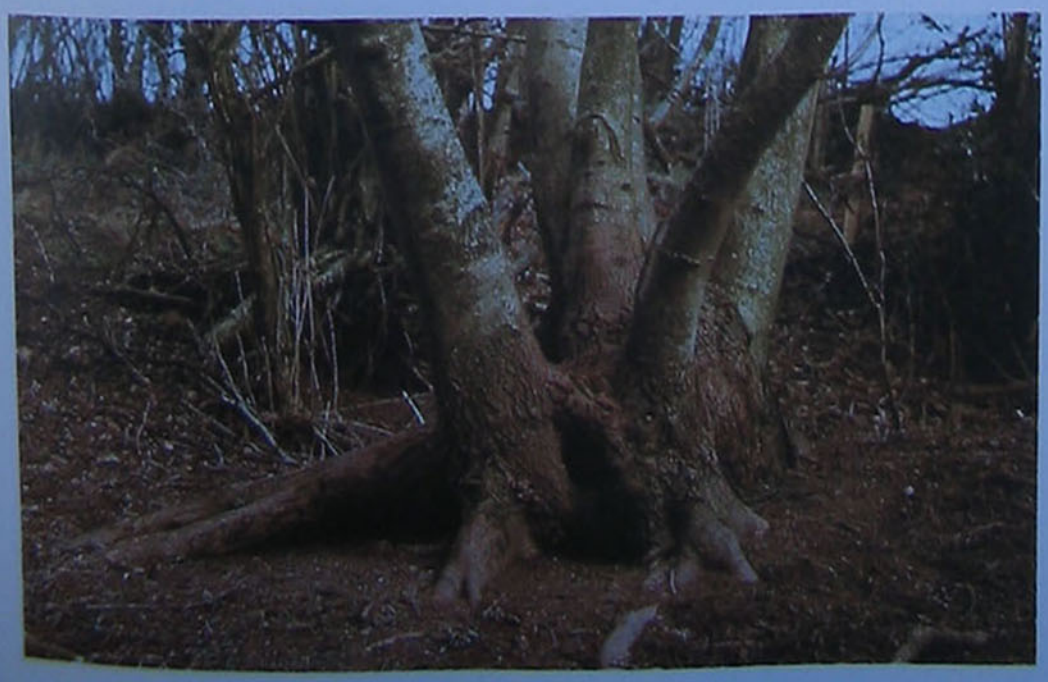
a female ready to mate. He was deterred from entering the sow's domain by the scent she deposited at the entrance. Instead, with loud vibrant whinnying purrs, he would try to call her out to establish her sexual condition by scenting her hind-quarters. Three weeks after giving birth she did come into oestrus and over the following three nights the boar mated with her repeatedly. On one occasion they were paired for nearly an hour before she was free to feed before returning to her cubs.

By early March the cubs were growing fast and she had to spend more time foraging. On dry nights she was able to bring back fresh bedding to replace the old which quickly became fouled by the cubs. Bundle after bundle of dead grass was collected from the upper pasture and dragged back through the copse, clasped under her body and kept in place by her chin as she worked her way backwards to the sett.

April-May The cubs began to be more adventurous. One night when the sow returned she found all three near the entrance and she suckled them there. Later that night they were bold enough to follow her out, but they did not stray far. From then on they emerged each night for short spells. The sow would lie near the entrance and the cubs played together, clambering over her body and nipping at her ears or tail. When she left they retreated below ground.

In early May she started to wean them and when she went off to forage they followed. Finding some succulent morsel, she would summon the cubs with a low staccato call. In this way they learnt the techniques of foraging and what was edible. By the end of the month the sow's milk had dried up and the cubs were feeding independently.

June-August By the second week in June the ground was hard and food scarce as there had been no rain for three weeks. The sow, no longer suckling, could forage further afield and find sufficient to keep her going, but a drought following weaning was a dangerous time for the cubs. One of her cubs had always been smaller and less vigorous. It would wander off each night and find a few food items, but it became progressively weaker. One night the sow discovered its emaciated body not far from the sett. She scented it carefully, but then ignored it and continued her own relentless search for anything edible. The



next day the weather broke and food was again easier to find.

At the end of June the farmer made his hay which lay in deep swathes. The sow found it the next night, and as a source of bedding it was irresistible. She made many trips to collect it and the excess was piled up outside one of the entrances. For some weeks after this it was used by the badgers when grooming or playing. One evening the boar curled up in it and went to sleep for an hour before going off to forage.

Towards the end of July the ripening oats were a useful source of food. The sow's technique was to knock down some straws with a front foot and pass the ends through her half-open mouth to sieve off the grain. In early August the field was cut, but the gleanings were useful to supplement her diet for most of the month.

On other nights she would search for beetles under the cowpats, dig for leatherjackets among the grass roots or work the hedgebanks for a nest of voles or even the occasional hedgehog.

September to mid-November During this period feeding from dusk to dawn was the sow's main preoccupation. It was the time for building up fat for the winter. One pouring wet night she was catching five or six earthworms a minute, sucking them up from the surface of the ground like spaghetti. After two or three hours she was so full she could hardly move, so she curled up under the hedgebank and went to sleep. A few hours later she awoke, her meal largely digested, so she filled her stomach once more before retiring.

One night she located a wasps' nest by the sound of the buzzing. She dug into the nest from above, her coat fluffing out like a bottle brush in her excitement. This was just as well as it reduced the likelihood of the enraged wasps reaching her skin to sting. By morning little was left of the nest. Blackberries were a favourite food on dry nights when earthworms were unavailable. She would neatly pick off the berries one by one. The apple orchard was also coming into its own as windfalls were abundant.

Mid-November to December A sharp spell of frosty weather in mid-November temporarily put an end to regular feeding. The sow had already put on much fat and was lethargic. For several nights she did not emerge, but slept curled up in some bedding. This was the time when the tiny blastocysts (developing eggs) inside her womb were about to implant. Before implantation the level of sex hormones in her blood increased, causing the lining of the womb to become receptive. Since they were fertilised in late February, the eggs had remained in her womb as glistening spheres no more than a millimetre or so in diameter. What triggered the increase in hormones now is not known for certain. It could have been the increase in night length or temperature change, but perhaps extra hormones stored in the fat during delay were released as the sow used up her fat during her semi-dormant period. Now the eggs became embedded in the wall of her womb and started to grow rapidly. A placenta soon formed and the foetuses then benefited from the sow badger's food supply and oxygen brought to them continuously by the blood stream.

Next year her cubs would be born late in January, a little earlier than last year. For the rest of the month she foraged on suitable nights, but there was no urgency to feed as she was well provided for. She could wait until the new year before preparing for the arrival of a new family.

It was November. The cubs were now almost as big as their mother and they made longer excursions away from the sett. One night the male followed a scent trail leading to the road. Sliding down the 'up-and-over' (above) he was halfway across the road when a car approached fast. His instinct was to 'freeze' rather than to run, and this was his undoing. He was knocked on to the verge (below) and he died almost at once.